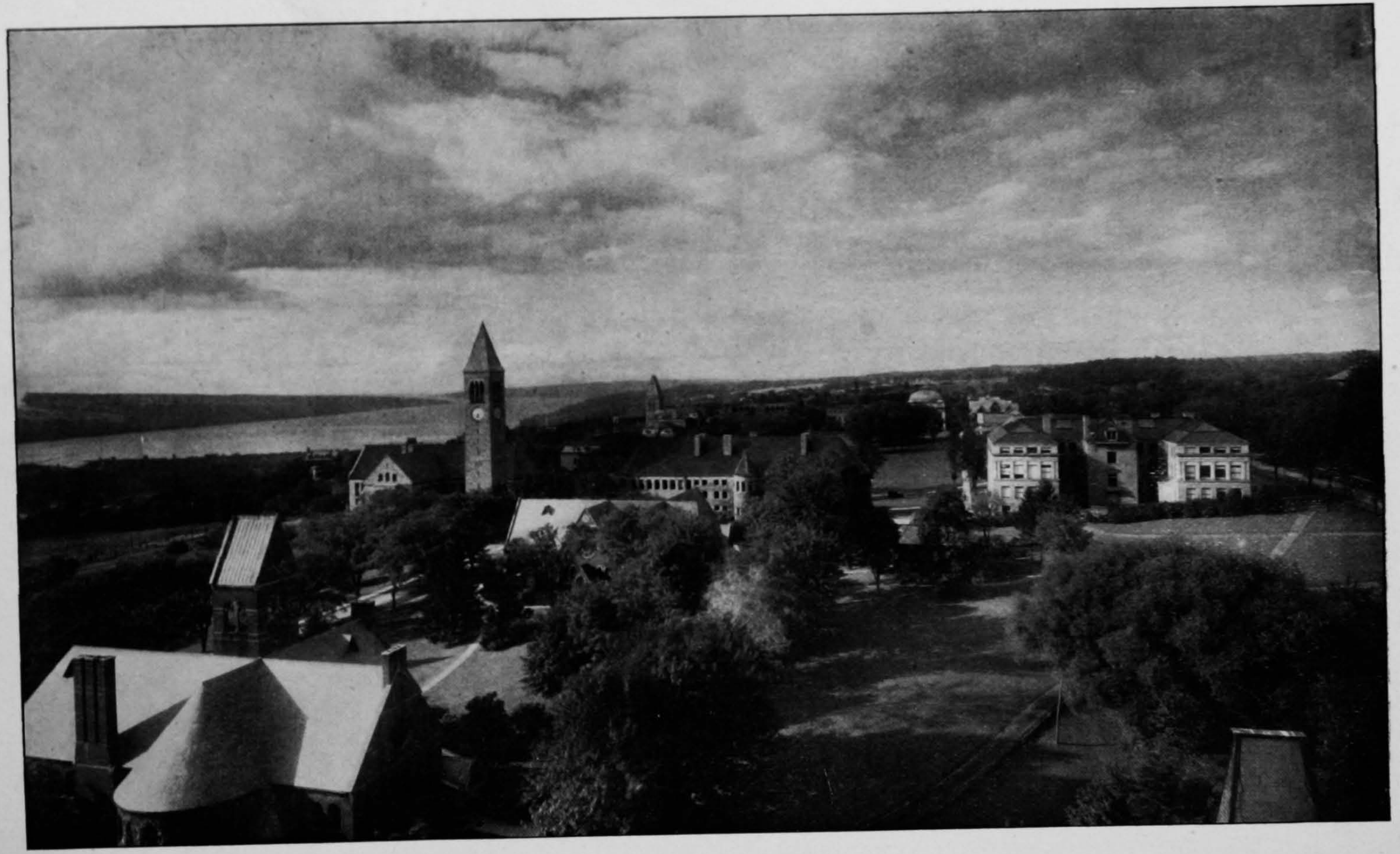

Looking North toward the Quadrangle with Sibley College in the Distance

CORNELL UNIVERSITY
OFFICIAL PUBLICATION

VOLUME VIII NUMBER 4

ANNOUNCEMENT OF THE SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

1917-18

JANUARY 15, 1917
PUBLISHED BY CORNELL UNIVERSITY
ITHACA, NEW YORK

This announcement is intended to give detailed information to prospective students in the Sibley College of Mechanical Engineering and the Mechanic Arts of Cornell University.

For general information concerning the University and its various colleges, the requirements for admission, etc., the General Circular of Information should be consulted. This and the other publications of Cornell University are listed on the last page of the cover of this pamphlet. Any one of the informational publications there mentioned will be sent gratis and post-free on application to The Secretary of Cornell University, Ithaca, N. Y.

CALENDAR

First Term, 1917-1918

Sept. 14,	Friday,	Entrance examinations begin.	
Sept. 24,	Monday,	Academic year begins. Registration of new students.	
Sept. 24,	Monday,	Examinations for University Undergraduate Scholarships begin.	
Sept. 25,	Tuesday,	Registration of new students.	
Sept. 26,	Wednesday,	Registration of old students.	
Sept. 27,	Thursday,	Instruction begins. President's annual address to the students.	
Sept. 29,	Saturday,	Registration, Graduate School.	
Oct. 16,	Tuesday,	Last day for payment of tuition.	
Nov.	Thursday,	Thanksgiving recess.	
Dec. 19,	Wednesday,	Instruction ends	} Christmas Recess.
Jan. 3,	Thursday,	Instruction resumed	
Jan. 11,	Friday,	Founder's Day.	
Jan. 26,	Saturday,	Instruction ends.	
Jan. 28,	Monday,	Term examinations begin.	

Second Term, 1917-1918

Feb. 9,	Saturday,	Registration, undergraduates.	
Feb. 11,	Monday,	Registration, Graduate School.	
Feb. 11,	Monday,	Instruction begins.	
Mar. 1,	Friday,	Last day for payment of tuition.	
April 3,	Wednesday,	Instruction ends	} Spring Recess
April 11,	Thursday,	Instruction resumed	
May 25,	Saturday,	Navy Day.	
June 5,	Wednesday,	Term examinations begin.	
June 19,	Wednesday,	Commencement.	

First Term, 1918-1919

Sept. 13,	Friday,	Entrance examinations begin.
Sept. 23,	Monday,	Academic year begins. Registration of new students. Scholarship examinations begin.
Sept. 24,	Tuesday,	Registration of new students.
Sept. 25,	Wednesday,	Registration of old students.
Sept. 26,	Thursday,	Instruction begins. President's annual address to the students.

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CORNELL UNIVERSITY

Cornell University was incorporated under the laws of the State of New York on April 27, 1865, and was opened on October 7, 1868.

By the Morrill Land Grant Act (July 2, 1862), Congress granted to the several states certain public lands from the sale of which should be established at least one institution of higher learning in each state. By the act of April 27, 1865, the Legislature of New York State granted its share of these lands to the foundation of Cornell University.

To this combination of federal and state beneficence, Ezra Cornell added the resources of his own private fortune, and through his effort the University was established.

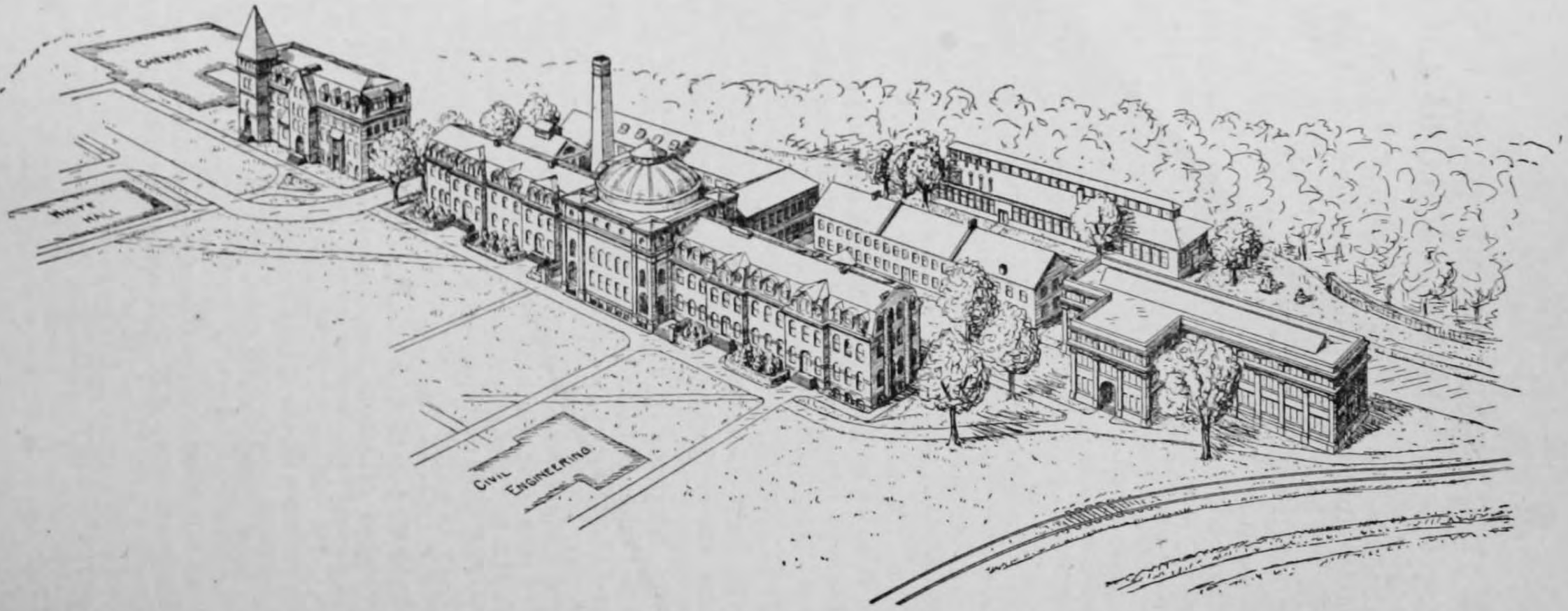
With the exception of the New York State Colleges of Agriculture and of Veterinary Medicine, which were founded and are supported almost entirely by the New York State Legislature with the aid of the federal government, the University in the main is supported by the income from the original endowment and from the funds donated subsequently by various benefactors.

The University is at Ithaca, New York, a city of fifteen thousand inhabitants, located at the south end of Cayuga Lake. The University Campus, lying high on the slope of the hills east of the town, commands a view of the western hills and of the valley and lake, which is of exceptional beauty.

The University, with an instructing staff numbering about eight hundred and twenty, and a student enrollment of more than five thousand, is composed of the Graduate School (degrees A.M., M.M.E., Ph.D., etc.), and the following colleges:

The College of Arts and Sciences (degrees A.B., B.Chem.),
The College of Law (degree LL.B.),
The Medical College (degree M.D.),
The New York State Veterinary College (degree D.V.M.),
The New York State College of Agriculture (degree B.S.),
The College of Architecture (degree B.Arch.),
The College of Civil Engineering, including Hydraulics and Sanitary Engineering (degree C.E.).
The Sibley College of Mechanical Engineering and the Mechanic Arts, including branches of Mechanical, Electrical, Industrial and Mining Engineering (degree M.E.).

The students of the Sibley College of Mechanical Engineering, constituting nearly one-fifth of the total number in the University, are thus associated with the faculties and students of other colleges, and by this intellectual stimulus in many fields other than engineering, are broadened and given a clearer understanding of the relation of engineering to other human activities and interests.



Buildings of Sibley College

SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
Albert William Smith, B.M.E., M.M.E., Dean of the Faculty, and Professor of Power Engineering, in charge of the Department of Power Engineering.
Rolla Clinton Carpenter, M.S., C.E., M.M.E., LL.D., Professor of Experimental Engineering.
Dexter Simpson Kimball, A.B., M.E., Professor of Machine Design and Industrial Engineering, in charge of these Departments.
George Robert McDermott, Professor of Structural Design.
Herman Diederichs, M.E., Professor of Experimental Engineering, in charge of the Department.
Alex Gray, B.S. in C.E., M.S. in E.E., Whitworth Scholar, Professor of Electrical Engineering, in charge of the Department.
William Nichols Barnard, M.E., Professor of Power Engineering.
Vladimir Karapetoff, C.E., Professor of Electrical Engineering.
Edgar Harper Wood, M.M.E., Professor of Mechanics of Engineering, in charge of the Department.
Calvin Dodge Albert, M.E., Professor of Machine Design.
Albert Edward Wells, Professor of Machine Construction, in charge of the Department.
Frank Oakes Ellenwood, A.B., Professor of Power Engineering.
Will Miller Sawdon, B.S., M.M.E., Assistant Professor of Experimental Engineering, assigned to Engineering Research.
Walter Stebbins Ford, M.E., Assistant Professor of Electrical Engineering.
George Burr Upton, M.M.E., Assistant Professor of Experimental Engineering.
Leslie David Hayes, M.E., Assistant Professor of Machine Design.
Seymour Stanton Garrett, C.E., Assistant Professor of Mechanics of Engineering.
Victor Raymond Gage, M.E., Assistant Professor of Experimental Engineering.
Robertson Matthews, M.E., Assistant Professor of Power Engineering.
Clarence Walter Ham, M.E., Assistant Professor of Machine Design.
Myron A. Lee, M.M.E., Assistant Professor in Machine Design.
John George Pertsch, Jr., M.E., Assistant Professor in Electrical Engineering.
Clarence Andrew Peirce, A.B., M.E., Assistant Professor in Power Engineering.
Joseph Franklin Putnam, M.E., Assistant Professor in Electrical Engineering.
Charles Harold Berry, M.M.E., Assistant Professor in Power Engineering.
Frank Girard Tappan, A.M., M.E., Instructor in Electrical Engineering.
W. Rodney Cornell, C.E., B.Sc., Instructor in Mechanics of Engineering.
Henry Mark Parmley, M.M.E., Instructor in Machine Design.
Fred Edgar Klinck, M.E., Instructor in Experimental Engineering.
Warren Howard Hook, M.E., Instructor in Experimental Engineering.
Clarence Ellsworth Townsend, M.E., Instructor in Machine Design.
William Cyrus Ballard, M.E., Instructor in Electrical Engineering.
Alexander Chilson Stevens, M.E., Instructor in Electrical Engineering.
Robert Franklin Chamberlain, M.E., Instructor in Electrical Engineering.
William Jacob Diederichs, M.E., Instructor in Experimental Engineering.
Ralph Burnette Day, M.E., Instructor in Mechanics of Engineering.
Harold Warner Brown, B.S., M.M.E., Instructor in Electrical Engineering.
Enoch Francis Garner, M.E., Instructor in Machine Design.
Roy Edwards Clark, M.E., Instructor in Power Engineering.
Louis Jacquelin Bradford, B.S., Instructor in Machine Design.
Percy George McVetty, M.E., Instructor in Research Engineering.
William Deans, jr., M.E., Instructor in Electrical Engineering.
Adam Clark Davis, M.E., Instructor in Experimental Engineering.
Charles Edwin Thomas, M.E., Instructor in Experimental Engineering.

Fred Stillman Rogers, M.E., Instructor in Machine Design.
E. Richard Page, B.S., Instructor in Electrical Engineering.
Norman Nevil Tilley, M.E., Instructor in Experimental Engineering.
Harold Howard Clark, M.E., Instructor in Machine Design.
George David Floyd, B.Sc. in Arts, B.Sc. in E.E., Instructor in Electrical Engineering.
Frederick George Switzer, M.M.E., Instructor in Hydraulics.
James Homer Hotchkiss, M.M.E., Instructor in Mechanics of Engineering.
Harold Charles Perkins, M.E., Instructor in Mechanics of Engineering.
William Emerson Mordorff, M.E., Instructor in Machine Design.
Elbert Aldrich Taylor, M.E., Instructor in Machine Design.
Robert Gephard Meyler, M.E., Instructor in Machine Design.
Hugo N. Diederichs, Instructor in Machine Design.
William Cook Andrae, M.E., Instructor in Machine Design.
Frederick William Armbruster, B.S., Instructor in Machine Design.
Paul Fenton, M.E., Instructor in Machine Design.
Joseph William Gavett, jr., M.E., Instructor in Experimental Engineering.
Carlos Child Knox, B.S. in M.E., Instructor in Experimental Engineering.
George Francis Bason, M.E., Instructor in Electrical Engineering.
Alejandro R. Cota, M.E., Instructor in Electrical Engineering.
Ralph Berry Stewart, B.S., Instructor in Electrical Engineering.
Martin Collins Hughes, B.S., Instructor in Electrical Engineering.
George Austin Worn, Instructor in Machine Design.

Assistants

James Eugene Vanderhoef, Foreman of Foundry.
Walter Liston Head, Foreman of Forge Shop.
Leroy Hooper, Foreman of Pattern Shop.
Birdette Newton Howe, Assistant in Machine Shop.
Howard Stanley Bush, Assistant in Pattern Shop.
Charles Albert Brooks, Assistant in Forge Shop.
William Benjamin Buck, Assistant in Machine Shop.
Nicholas Barnard Block, Assistant in Machine Shop.
Deward Armenias Evans, Assistant in Foundry.
Harry William Price, Assistant in Pattern Shop.
William Frederick Head, Assistant in Forge Shop.
Carlos Elmer Harrington, Assistant in Machine Design.
Chester Carroll Hough, Assistant in Machine Design.
Davies Kirkland Banks, Assistant in Power Engineering.
John George Gates, Assistant in Power Engineering.

George Washington Race, Mechanician in Sibley College.
Edward Warren Gregory, Mechanician.
Charles Alfred Culligan, Mechanician.
Charles Bedell, Engineer.
James Alonzo Bush, Mechanician.

Margaret Isabelle Colquhoun, Clerk in Experimental Engineering.
Edith Nourse Robinson (Mrs.), Secretary to the Dean.
Maude Newman, Clerk of Records.
Frank Latta Fairbanks, M.E., Librarian of Sibley College.

PURPOSES OF INSTRUCTION

Sibley College is organized, primarily, to teach the fundamental principles, theoretical and practical, that underlie the various branches of mechanical, electrical, and mining engineering. In addition to this there is included such work in pure and applied economics as is needed by the engineer of the present time. In the senior year students may take any one of the following options:

A. **Electrical Engineering.**
B. **Heat-Power Engineering.** Steam Engineering or Internal Combustion Engineering.
C. **Structural and Plant Engineering.**
D. **Ship Design and Construction.**
E. **Industrial Engineering.**
F. **Mining Engineering.**

Since the work in any one of these options includes only a portion of the time of one academic year out of four, it follows that specialization cannot be carried very far; in fact the faculty of Sibley College holds the opinion that the duty of a technical school to its undergraduates is to train them thoroughly in fundamental subjects and that the four year course is none too long for this purpose; hence the pressure to introduce narrow specialization early in the course has always been firmly resisted.

It is well recognized that theoretical instruction must be supplemented by experience in practice and by contact with life before one can attain his greatest usefulness in the profession; hence, in Sibley College, an effort is made to bring the student into contact with teachers who are closely in touch with commercial engineering practice to the end that he may thus become familiar with problems encountered in modern engineering and with commercial methods of solving them. It is hoped in this way to shorten somewhat the period of adjustment for the graduate when he begins actual engineering work.

The success of an engineer has come more and more to depend upon his ability to meet men of education and culture on equal terms. Since the work in the regular four year course in this college is almost wholly technical, it is preferable that the student before entering the College should have a thorough general education, and, if possible, the training of a liberal college course. Those who have not had this broader education should, if possible, devote one or two years to subjects taught in the College of Arts and Sciences. A five year course for Sibley students, including the equivalent of one year of this broader training, is outlined on pages 29 and 30; and a six year course leading to the degrees of A.B. and M.E. is described on page 31. The entrance requirements for these courses demand less mathematical preparation than is specified for the four year engineering course.

In addition to the prescribed courses in Sibley College those students who have the necessary time available may elect, with the permission of their class adviser, any course in any college of the University, provided they have had the required preparation for the work.

OPPORTUNITIES FOR EMPLOYMENT

Mechanical Engineering underlies nearly all branches of the industries: its province includes the design, construction, operation and testing of steam engines, steam turbines, boilers and power plant auxiliaries, gas and oil engines with their auxiliaries, hydraulic machinery, pumping engines, railway equipment, compressed air machinery, ice making and refrigerating machinery, equipment for heating and ventilation, machine tools, mill equipment and transmission machinery. The work of the mechanical engineer includes the planning of power plants and factories, the selection and installation of their equipment, the development of the systems of operation and of manufacturing processes and the organization and administration of industries. **Electrical Engineering** includes the design, construction, operation and testing of electrical equipment used for the generation, transmission and utilization of electrical energy. **Mining Engineering** concerns itself with mining methods and machinery and the metallurgical processes.

From the foregoing very brief outline of some of the fields covered by the branches of engineering for which the students of Sibley College are fundamentally prepared, it is seen that the opportunities for the graduates to secure employment are extremely broad. The graduates, after gaining requisite experience in practice, usually occupy such positions as designers, supervisors of construction, inspectors, testers, research engineers, superintendents of departments, works managers, efficiency engineers, specialists in welfare work and in labor problems, consulting engineers, insurance investigators, commercial representatives, engineering salesmen, educators, and managers and presidents of commercial organizations.

There has always been a dearth of men fitted to fill the higher positions in the engineering and business fields; and the salary and position that the graduate will eventually obtain depends not only on his engineering training but on his inherent ability, industry, initiative, capacity to recognize and seize opportunities as they arise, and on his other personal qualities. The young man who has just graduated from Sibley College has little difficulty in securing immediate employment with salary sufficient for self-support, and if he eventually shows the proper qualifications he may rise to the highest positions attainable in engineering and business fields.

BUILDINGS AND EQUIPMENT OF SIBLEY COLLEGE

The Sibley College of Mechanical Engineering and the Mechanic Arts receives its name from the late Hiram Sibley of Rochester, who between the years 1870 and 1887, gave $180,000 toward its endowment and equipment. Mr. Hiram W. Sibley has added more than $150,000 for later constructions and equipment. The Sibley buildings are situated at the north end of the Campus, and stand upon ground leased from the University for the purposes of the College, under an agreement with the late Hiram Sibley. There are six large buildings in the group.

The main building is three hundred and seventy feet long, fifty feet in width, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices, class rooms, and a large and well-lighted auditorium.

Franklin Hall is occupied on its first two floors by the Department of Electrical Engineering, which in addition uses temporarily a portion of Rand Hall.

The Department of Experimental Engineering occupies two two-story buildings, each about one hundred and fifty feet long by forty feet wide, besides a boiler plant thirty by forty feet, a refrigeration laboratory thirty by forty feet, and the east basement of the main building.

Rand Hall has recently been added to the Sibley College group (at a cost of $60,000) through the generosity of Mrs. Florence O. R. Lang. This building is a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr., the father, uncle, and brother of the donor. It is a three-story building, the main portion of which is one hundred and seventy feet long and fifty feet wide; it contains the machine shop and pattern shop, and a portion is used temporarily for the electrical laboratories.

The foundry and forge shops occupy a one-story building one hundred and eighty feet long and forty feet wide.

MECHANICAL LABORATORIES

The instruction in the Department of Experimental Engineering is given in several separate laboratories, each of which is thoroughly equipped with the machines, apparatus, and instruments necessary for instruction in research.

The Materials Testing Laboratory. This laboratory is equipped for tension and compression tests with an Olsen 300,000 pound machine, a Riehlé 100,000 pound machine, a 200,000 pound Emery hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse tests there is a Riehlé machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There are two Thurston autographic torsion machines, one Olsen torsion machine of 200,000 inch-pounds capacity, and two Upton-Lewis fatigue testing machines. The equipment includes extensometers, a cathetometer, gas furnaces, tempering baths, and all other apparatus required for the determination of the physical qualities of engineering materials under tensile, compressive, transverse, and torsional stress, and under different kinds of heat treatment.

The Steam Laboratory. In this laboratory there is a 150 H. P. triple expansion Allis-Corliss engine so fitted up that it may be operated as a simple, compound, or triple expansion engine, condensing or non-condensing. There are also several smaller engines, including a Russell, a Harris-Corliss, a Payne, a Troy, a Wickes Bros. automatic engine, and a three-cylinder, compound, Laidlaw-Dunn-Gordon steam pump capable of delivering 300 gallons of water per minute against a pressure of 300 lbs. per square inch. There are three surface condensers which may be connected with these engines as desired. There is a 35 kw. horizontal Curtis turbine and a 15 kw. De Laval turbine which drive electric generators and may be run condensing or non-condensing.

A two-stage steam-driven Ingersoll-Rand compressor and three air-brake pumps of different types, together with meters, nozzles, and other instruments, are used for routine tests. This part of the laboratory also has several fans that can be arranged and equipped for testing.

The apparatus and instruments used for engine testing comprise about 80 indicators of different types, about 75 steam gauges, a number of calorimeters for the determination of the quality of steam, speed counters, tachometers, planimeters, etc., besides a number of dynamometers of various kinds.

The boiler section of this laboratory has one 150 H. P. Babcock & Wilcox water-tube boiler of the marine type, and one 100 H. P. Babock & Wilcox water-tube boiler of the standard type, both of which are fitted with internal superheaters. There is also one 80 H. P. Heine water-tube boiler and one 25 H. P. Roberts safety boiler connected with a Foster independent superheater. The auxiliary apparatus consists of a Cochrane open heater, a Wainwright closed heater, steam pumps, traps, injectors, etc. A full set of scales, measuring tanks, gauges, flue gas apparatus, separating and throttling calorimeters, pyrometers, etc., complete the boiler equipment.

The Gas Engine Laboratory. The equipment includes an 8 H. P. Westinghouse gas engine, an 8 H. P. Olds gasoline engine, an 8 H. P. Fairbanks gasoline engine, a 6 H. P. "Ingeco" oil engine, a 6 H. P. Hornsby-Akroyd oil engine, a 15 H. P. Hornsby-Akroyd oil engine, a 16 H. P. Acme gas engine run on producer gas from a 15 H. P. suction gas-producer, and a 30 H. P. three-cylinder Westinghouse gas engine with gas producer and a 45 H. P. McIntosh & Seymour Diesel engine direct connected to a D. C. generator. Hot air engines are represented by a Rider and an Ericsson engine. This engine equipment is chosen to give as great a variety as possible in the fuels used, types of governing, etc.

The supply of testing instruments includes several outside spring indicators, optical indicators, and a manograph. For temperature measurements there are available high-reading thermometers and pyrometers of the expansion and electrical types.

The Hydraulic Laboratory. This laboratory contains the following machines and apparatus: a 6-inch single-stage De Laval centrifugal pump; a 2½-inch two-stage Worthington centrifugal pump; a 12-inch Doble water wheel; a 10-inch Trump turbine; several Pelton wheels and hydraulic rams; sets of weir boxes with various types of weirs and nozzles for the determination of coefficients of discharge; various types of water meters and other apparatus for measuring the flow of water, such as Pitot tubes, Venturi meters, current meters, etc.

The Oil Testing Laboratory. This laboratory contains a Cornell oil-testing machine, a Thurston standard railway-testing machine, and several smaller Thurston machines. The rest of the equipment consists of several viscosimeters of different types, together with the necessary hydrometers and thermometers.

The Refrigeration Laboratory. For the study of refrigeration the mechanical laboratory possesses a very complete York refrigerating plant having a capacity of 15 tons of ice, and a 2 ton York absorption machine.

The Cement Laboratory. This laboratory not only contains the ordinary apparatus for the testing of cement and concrete, but in addition is equipped with crushing and grinding machinery and a small vertical kiln for making investigations on the manufacture of cement from raw material.

The Fuel Testing Laboratory. This laboratory contains a complete equipment of fuel calorimeters, and other apparatus needed for the determination of the composition and calorific value of fuel, whether gaseous, liquid, or solid.

THE ELECTRICAL EQUIPMENT

The Lecture Equipment. The lecture room is exceptionally well provided with display apparatus and with apparatus especially designed for demonstration

purposes. All types of electrical machinery may be operated on the lecture table and a 60,000 volt transformer is provided for insulator testing.

The Dynamo Laboratories. These laboratories are provided with a great variety of standard and special machines for both direct and alternating current work, along with the necessary meters and control equipment. Among the special pieces of equipment are a street car truck with motors and also a complete outfit for exhibiting in actual operation the multiple unit system of electric car control.

The Standardizing Laboratory. This laboratory is equipped with the necessary potentiometers, galvanometers and standards for the calibration of instruments, and the testing of materials used in electrical work. There is also a G.E. oscillograph for work on wave form.

The Wireless Laboratory. This laboratory has a 5 kilowatt, 500 cycle sending set, also a 2-kilowatt, 60 cycle set, both being equipped with rotary and also with quenched spark gaps. The receiving equipment includes crystal, audion and other detectors. The aerial is about 500 feet long and, by means of some of the new supersensitive apparatus, a receiving range of 5000 miles is obtained.

The power for the various laboratories is obtained from the University Hydro-electric Plant, which contains large three-phase alternators, direct driven by both impulse and reaction water-wheels. This plant is complete in every respect and is used for inspection.

ENGINEERING RESEARCH EQUIPMENT

The Research Division of the Department of Experimental Engineering has all the equipment and resources of the various departments of Sibley College available for use in connection with its investigations. (See announcements of these departments.) It is also possible, in most instances, to arrange to use the engineering and scientific equipment of the other Colleges of the University. This division has some special equipment including a belt and pulley testing machine and a 150 H. P. electric dynamometer for testing automobile motors.

WORK SHOPS

The foundry occupies floor space of about 4800 square feet, and has an equipment for the production of iron and composition castings. The methods of producing duplicate work are demonstrated by moulding machines of different types selected to illustrate the production of castings of various kinds at lowest labor cost.

The forge shop has the usual equipment of standard forges and small tools, as well as a modern drop-forge plant. Forging by the drop-hammer method, and power press work are demonstrated and discussed.

The pattern shop occupies the top floor of Rand Hall with floor space of 8,440 square feet. The work given the students in this department includes the use of hand and power operated tools under instructors who are skilled in the trade of pattern making.

The machine shop is located on the ground floor of Rand Hall with the same floor area as the pattern shop. It is equipped with an electric traveling crane and representative modern machine tools selected with a view of demonstrating manufacturing methods. A part of the work-shop equipment is installed to illustrate the latest practice in production with specialized labor-saving machinery.

The students are not expected to become skilled operators of the machines of this class, but to acquire a general knowledge of their possibilities in the kinds of work to which they are adapted. The equipment is arranged in groups, each under the charge of an instructor who has made a special study of the machinery in his group.

ENGINEERING LIBRARY

The Library of Sibley College, which is a branch of the University Library, contains a splendid equipment of reference books and periodical literature relating to the fields of engineering taught in Sibley College and to the allied branches of learning. In addition to this library the student has access to the University Library and to the special libraries of the other Colleges and Departments of the University.

SCHOLARSHIPS, PRIZES, AND LOANS

A special pamphlet on prizes may be secured from the Secretary of the University. A description of the scholarships open to entering freshmen in all colleges is given in the General Circular of Information. Regarding Graduate Scholarships, Fellowships, etc., see the Announcement of the Graduate School.

State Tuition Scholarships. (Awarded by New York State). Under the law of the State of New York the Commissioner of Education is empowered to award annually a number of free scholarships in Cornell University equal to the number of Assembly districts in the State of New York. Each scholarship entitles the holder to free tuition for four years beginning in the September immediately following the award of the scholarship.

All scholarship holders must satisfy the regular requirements for admission to one of the colleges of the University.*

State Cash Scholarships. (Awarded by New York State.) Under the law of the State of New York (Chapter 292, Laws of 1913), State Scholarships have been established in the several counties of the State, to be maintained by the State as provided by law. Five such scholarships are to be awarded each county annually for each assembly district therein. Each such scholarship will entitle the holder thereof to the sum of one hundred dollars for each year of his attendance upon an approved college in this State during a period of four years.*

University Undergraduate Scholarships. (Awarded by the University.) Eighteen University Undergraduate Scholarships, each continuing for two years and of an annual value of $200, are offered each year to members of the incoming freshman class. The award is made on the basis of a special competitive examination held in Ithaca in September between the period of entrance examinations and the opening of the University. Every candidate for such a scholarship must have satisfied the entrance requirements for one of the colleges of the University. Holders of New York State Scholarships are eligible for University Undergraduate Scholarships. The University Undergraduate Scholarships will be awarded on the basis of examinations in three of the seven following subjects: English, Greek, Latin, French, German, Spanish, Elementary Mathematics,

*For particulars in regard to the awarding of State Scholarships, application should be made to the Commissioner of Education, Albany, N. Y.

Advanced Mathematics. Certain combinations of these subjects are specified.*

The Buffalo Alumni Association Scholarship of an annual value of $200 is offered to students who are residents of Erie or Niagara County, New York.*

The Student Fund of the Cornell Club of Rochester provides for a loan of an annual value of $200.*

Graduate Fellowships. There are three fellowships in Mechanical and Electrical Engineering, with annual value of $400 each. (See Announcement of the Graduate School.)

The attention of **Sibley students** is directed particularly to the following paragraphs:

The Frank William Padgham Scholarship. This scholarship, founded in 1892 by Amos Padgham of Syracuse, New York, in memory of his son, Frank William Padgham, a graduate of Sibley College of the class of 1888, entitles the holder to free tuition and fees in the regular course in Sibley College of Mechanical Engineering. It cannot be held in connection with a New York State Scholarship. The Frank William Padgham Scholarship will be awarded to the candidat- who has had his preparatory education wholly or in part in the public schools of Syracuse, New York, and who, having been admitted to the regular course in Sibley College, shall pass the best examination in a competitive examination on the following studies selected from those that may be offered for admission to Sibley College: 1. solid geometry; advanced algebra; plane trigonometry; 2. third year German; 3. third year French; 4. English. Of these subjects the candidate must take three, including mathematics. The examination for the Padgham Scholarship is held at the same time as the University Undergraduate Scholarship examinations; it is, however, a special examination and the candidate must declare his intention to enter the Padgham Scholarship examination and state his qualifications therefor to the Registrar, who will issue the usual permit to enter the examination. In case no one qualifies for this scholarship in the foregoing manner, the Faculty of Sibley College may, with certain restrictions, recommend the awarding of the scholarship to some worthy applicant, preferably one from Syracuse. Upon request, detailed information regarding the examinations and the awarding of this scholarship will be furnished by the Dean of Sibley College or by the Registrar of Cornell University.

Sibley Prizes in Mechanic Arts. Under the gift of the late Hiram Sibley, made in 1884, the sum of one hundred dollars will be annually awarded in five prizes to juniors and seniors in Sibley College who have received the highest marks in scholarship in at least three full terms of work required in the Sibley College course and done in that college. The prizes are $30, $25, $20, $15 and $10.

The Fuertes Memorial Prizes in Public Speaking, founded by Charles H. Baker, C.E., '86, consisting of $125, $35, and $20 respectively, are awarded annually to those members of the junior and senior classes in the Colleges of Engineering and Architecture, who may be selected after competitive trial in public speaking. The orations delivered in competition for these prizes are to be original compositions on technical subjects and must be argumentative in character. In making the awards both the character of the argument and the manner of delivery will be considered.

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*For details see the General Circular of Information.

*The Wurts Loan Fund, the gift of Alexander Jay Wurts, in memory of his mother Laura Jay Wurts, was founded in 1912 to assist needy students of the two upper classes in Sibley College. Upon the recommendation of the Dean of Sibley College, loans from the income from this fund may be awarded by the Faculty of Sibley College, with the approval of the Treasurer, to one or more students each year.

PREPARATION FOR ADMISSION

As the instruction in Sibley College is almost entirely of a scientific or engineering character, and as, at best, the student in the four year course has only very limited opportunities for instruction along broader lines, it is desirable that the training for entrance to that course should be as liberal as possible with stress on subjects like language and history, and with physics and chemistry deferred until after entering the University.

While three years of any one of the foreign languages listed on page 15 will be accepted by this college as satisfying the language requirement for admission, prospective students are strongly advised to study German and French, not only for their cultural value but for their engineering literature. It is of advantage for those entering the engineering courses to have had some instruction in free-hand sketching.

Students who have had some engineering experiences usually gain more than others from the courses of Sibley College; hence it is recommended that prospective students spend at least one summer vacation in touch with some kind of engineering work.

As already mentioned, it is desirable for the student to obtain, if possible, the training of a liberal college course before entering Sibley College, and those who have not had this broader education are recommended to take either the five year course or the six year course, if they can afford the additional time and expense involved.

ADMISSION AND CLASSIFICATION

The following five classes of students are admitted to the work of the Sibley College of Mechanical Engineering, and the Mechanic Arts:

1. Persons who desire to begin as freshmen, the regular four year undergraduate courses relating to mechanical, electrical, industrial or mining engineering and leading to the degree of Mechanical Engineer. (See page 16 for requirements for admission, pages 24 to 28 for course relating to mechanical, electrical and industrial engineering, and pages 28 to 29 for course relating to mining engineering.)

2. Persons who desire to begin as freshmen in the five year course leading to the degree of Mechanical Engineer. (See pages 16, 29 and 30).

3. Persons who have already attended some technical or similar institution and desire to enter with advanced standing the regular course in Sibley College leading to the degree of Mechanical Engineer. (See page 17).

4. Persons who desire to enter as special students not candidates for the degree of Mechanical Engineer. (See page 17).

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*For information regarding the other loan funds and the opportunities for self support see the General Circular of Information or the pamphlet on Financial Assistance and Self-Help.

5. Graduate Students. (Registration in Graduate School of Cornell University. See Announcement of the Graduate School).

For the course of six years leading to the degrees of Bachelor of Arts and Mechanical Engineer, see page 31.

List of Subjects for Entrance to Sibley College

NOTE—The term unit means the equivalent of five prepared recitations a week for one year in a subject, or 120 sixty minute hours. Two hours of laboratory work is considered equivalent to one hour of prepared recitation. See General Circular of Information for detailed information.

Group *a*

Subject	Units
English No. 1	1½
English No. 2	1½
Algebra, Elementary	1
Algebra, Intermediate	½
Algebra, Advanced	½
Geometry, Plane	1
Geometry, Solid	½
Plane Trigonometry	½

NOTE

Four year Course: All seven units in Group *a* are required.

Five year Course: From Group *a* five units are required, including

English Nos. 1 & 2	3 units
Algebra, El	1 "
Geometry, Plane	1 "

Group *b*

Subject	Units
History—Ancient	½ or 1
" Modern	½ or 1
" American, Civics	½ or 1
" English	½ or 1
German—First Year	1
" Second Year	1
" Third Year	1
French— First Year	1
" Second Year	1
" Third Year	1
Greek— First Year	1
" Second Year	1
" Third Year	1
Latin— First Year	1
" Second Year	1
" Third Year	1
" Fourth Year	1
Spanish— First Year	1
" Second Year	1
" Third Year	1
Italian— First Year	1
" Second Year	1
" Third Year	1
Spherical Trigonometry	½
Physics	1
Chemistry	1
Physical Geography	½–1
Biology*	1
Botany*	½–1
Zoology*	½–1
Bookkeeping	½–1
Drawing†	½–1
Manual Training†	1
Any other High School Subject.	½–1

NOTE

Four year Course: From Group *b* eight units are required, including

Foreign Language (one).	3 units
History	1 "
Elective	4 "

Five year Course: From Group *b* ten units are required, including

Foreign Language (one) .	3 units
History	1 "
Elective	6 "

Among the electives may be included Intermediate Algebra, Advanced Algebra, Solid Geometry or Plane Trigonometry of Group *a*.

*If an applicant has counted Biology (1) he may not also offer Botany (½) or Zoology (½).
†Three hundred actual hours are required for one unit.

Credit for entrance subjects* may be secured in the following ways:

1. By passing the required Cornell University Entrance Examinations held in September in Ithaca and New York City, and in January in Ithaca.

2. By passing the College Entrance Examination Board Examinations held in June in various places. (Address the Secretary of the College Entrance Examination Board, 431 West 117th St., New York City.)

3. By passing the Regents' Examinations (for students who have prepared in New York State).

4. By presenting an acceptable school certificate.

For the regulations relating to admission at the beginning of the second term see next page.

1. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS IN THE FOUR YEAR COURSE

[All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University. All credentials relating to the admission of new students must be in the hands of the Registrar before September first.]

For admission to the four year course the applicant must be at least sixteen years of age and must satisfy either A or B of the following scholastic requirements.

(A) He must offer 15 units from the List of Entrance Subjects given on page 15, and besides including all of Group *a* (three units of English and four of Mathematics), he must offer from Group *b*, one unit of History, three units of one Foreign Language (ancient or modern, but preferably German or French) and four other units, preference being given to subjects other than Physics and Chemistry, as these are included in the engineering course; or

(B) He may offer, as a substitute for (A), either the Arts College Entrance Diploma, or the Science College Entrance Diploma, issued by the Department of Education of the State of New York, provided he receives credit for the four units of Mathematics of Group *a*.

2. REQUIREMENTS FOR ADMISSION TO THE FRESHMAN CLASS IN THE FIVE YEAR COURSE

[All correspondence concerning admission to the freshman class should be addressed to the Registrar of Cornell University. All credentials relating to the admission of new students must be in the hands of the Registrar before September first.]

For admission to the five year course the applicant must be at least sixteen years of age and must meet the following entrance requirements:

(A) He must offer fifteen units from the List of Entrance Subjects given on page 15 and must include English 3 units, Elementary Algebra 1 unit and Plane Geometry 1 unit (from Group *a*), 3 units in one Foreign Language and 1 unit of History (from Group *b*) and six other units from either group; or

(B) He may offer, as a substitute for A, either the Arts College Entrance Diploma, or the Science College Entrance Diploma, issued by the Education Department of the State of New York.

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*For details concerning entrance subjects and methods of admission see the General Circular of Information.

3. ADMISSION FROM OTHER COLLEGES

[All correspondence concerning admission from other colleges should be addressed to the Registrar of Cornell University.]

A student who, having already attended some technical or other institution of collegiate rank, desires to enter the regular course in the Sibley College of Cornell University, should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to Sibley College along with an official certificate from the institution already attended, of his honorable dismissal, his entrance examinations in detail, his terms of attendance and the amount of work that he has completed, and a detailed statement of the courses pursued. He should send also a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he expects to offer. If at the time of admission the student does not satisfy in full the entrance requirements for freshmen (see page 16) he must remove the deficiencies within one year after admission.

4. ADMISSION AT THE BEGINNING OF THE SECOND TERM

Certificates and credentials for admission at mid-year should be in the hands of the Registrar not later than January 15.

Students who meet in full the requirements for admission as freshmen in either the four year or the five year course may enter Sibley College at mid-year to pursue courses which will be specially outlined to suit each individual case and which will lead to the degree of Mechanical Engineer at the end of four and a half years.*

In order to secure admission at mid-year with advanced standing in the regular four year course in Sibley College, with a view to graduating in less than four years, the applicant must have attended an institution of collegiate rank and must secure credit for such university courses as will enable him, by attending during the remainder of the college year and (possibly) during the succeeding Summer Session, to substantially complete the year's work scheduled for the class he wishes to enter.

On application made to the Registrar on or before January 15 in any year, special entrance examinations in any of the University entrance subjects may be arranged for students who must be examined in one or more subjects to complete their requirements for admission at the middle of the year. These special entrance examinations will be held in Ithaca on or about January 25 of each year.

5. ADMISSION AS SPECIAL STUDENTS

[All correspondence concerning the admission of special students should be addressed to the Dean of Sibley College. All applications for admission must be made on the official blanks provided for the purpose and obtainable from the Dean.]

Men at least twenty-one years of age may be admitted as special students in mechanical engineering not candidates for a degree, provided they have had

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*Those meeting the requirements of admission to the five year course must complete all the Mathematics of Group *a* (page 15) before the following fall. But one unit of this Mathematics can be taken during the first term of attendance: further shortage may be removed by attending the following Summer Session or by taking the entrance examinations in the fall.

sufficient experience in some line of mechanical engineering to show that they are worthy of special consideration because of demonstrated aptitude in engineering branches, and provided they give evidence of ability to do creditable work in the College, and provided they have neither been previously admitted to the University as regular students nor have been refused admission.

They are required to have completed before admission the mathematical preparation of the regular students of either the four year or the five year courses (page 15) and may be held for examination in these subjects. There are no special courses for special students; such students must conform to either the four year course as outlined on pages 24 to 28, or to the five year course (pages 29 and 30), depending on their preparation. Upon fulfilment of all entrance requirements special students may become regular students and candidates for the degree of M.E. Special students will not, however, be permitted to make up deficiencies in entrance subjects by attending University instruction in those subjects.

6. ADMISSION AS GRADUATE STUDENTS

[All correspondence relating to graduate work and graduate fellowships should be addressed to the Dean of the Graduate School.]

In all departments in Sibley College, work is arranged to meet the special needs of graduate students and, in addition, the head of the Department of Experimental Engineering will co-operate in every way to assist the graduate students in mechanical and electrical engineering, and will aid in providing apparatus and other facilities for graduate work. Graduate students register in the Graduate School and not in Sibley College. To be registered as a candidate for the degree of Master of Mechanical Engineering, the student must have satisfied the equivalent of the entrance requirements and of the University subjects specified by Sibley College for the M.E. degree. There are three Fellowships in Mechanical and Electrical Engineering, which have an annual value of $400 each. For further information regarding admission, registration, fellowships, etc., see Announcement of the Graduate School.

PAYMENTS TO THE UNIVERSITY

[For detailed information regarding payments to the University and the expense of living in Ithaca, see the General Circular of Information.]

Briefly, students entering Sibley College are subject to a matriculation fee of $5 and to the following payments:

	1st Term	2d Term
University Tuition ($150 yearly)*	$85	$65
Sibley Fee ($25 yearly)†	12.50	12.50
Infirmary Fee ($6 yearly)	3	3

Each student is required to pay a fee of $2 per term for the use of a locker in the Drill Hall or Gymnasiums. Those taking laboratory courses in other colleges of the University must pay to the Treasurer a fee or deposit for materials used in the work. Payments must be made within 20 days after registration. A gradua-

*All tuition and other fees may be changed or increased by the Trustees to take effect at any time without previous notice.

†Students in the five year and four and one-half year courses need pay this fee for but eight terms.

tion fee of $10 must be paid ten days before graduation. The amount will be refunded should the degree not be conferred. Tuition is free to students holding New York State Tuition Scholarships.

A reinstatement fee of twenty-five dollars is charged to every student who has been dropped from the University for delinquency in scholarship or conduct, except for such delinquency in scholarship as is due to ill health or to other reasons beyond the student's control, in which case the fee may be remitted upon recommendation of the Dean of the College in which the student is registered.

Non-engineering students taking shopwork or laboratory work in Sibley College must pay for such instruction a fee of $3.50 per record hour. When a student has taken, while in a non-engineering college of the University, part of the work required for the M.E. degree, such student before receiving that degree shall be required to have paid to the University Treasurer such amount as would have been paid if all such work had been taken while registered in Sibley College. The University Treasurer is empowered to adjust the arrears to be paid in irregular cases arising under the foregoing requirements.

GENERAL OUTLINE OF INSTRUCTION

The instruction in mathematics, chemistry, physics, geology, and general economics is given in the College of Arts and Sciences. All other regular subjects in the course are of an engineering nature and are given in Sibley College in the following departments: 1. Machine Construction; 2. Machine Design; 3. Mechanics of Engineering; 4. Power Engineering; 5. Experimental Engineering; 6. Electrical Engineering; 7. Industrial Engineering.

The following is a brief outline of the scope and purposes of instruction in the various departments of Sibley College.

1. DEPARTMENT OF MACHINE CONSTRUCTION

The object of the instruction in this Department is not only to familiarize the student with modern shop operations and processes, and with the workability of materials used in engineering construction, but more particularly to give him instruction in the principles of manufacturing and duplication of parts, and in the selection and arrangement of shop equipment.

In the freshman year the student receives instruction in the foundry in moulding, core making, mixing of metals, operation of cupola, the use of moulding machines, etc., with consideration given to the methods and appliances for sweepwork, large work, and production in quantities; and he is given manual instruction in the forging and heat treatment of both iron and steel, supplemented with illustrations of drop-hammer work and methods used in manufacturing in large quantities.

In the sophomore year wood working is taught with the object not only of familiarizing the student with wood-working tools and machines and their use, but more especially to teach him pattern and core-box making. Instruction is also given in large pattern work and sweepwork.

In the junior year the principles of manufacturing are taught, supplemented by work of an illustrative character in the machine shop, where carefully graded

instruction is given in the use of measuring instruments, hand tools, and machine tools, including semi-automatic and automatic machines, and in the use of jigs and special fixtures for manufacturing in large quantities. The administration of this shop in particular is intended to illustrate as far as possible approved methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium plan, and other wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

2. DEPARTMENT OF MACHINE DESIGN

The courses in drawing, design and shopwork, are so organized as to secure the close correlation of these subjects. Many of the exercises in the drawing room, pattern shop, foundry, and machine shop involve work on the same machine parts. In this way the student has presented to him all the necessary steps from the inception to the production of finished machine parts.

Instruction in this Department begins with lettering, the use of drawing instruments, the elements of mechanical drawing according to the best practice in commercial drafting rooms, and descriptive geometry.

Following this the student is taught empirical design and the principles of mechanism. The drawing-room work in the latter course is closely related to the class-room instruction in cams, gearing, and linkages, with application to the kinematic design of machines.

After the student has received instruction in mechanism and applied mechanics, he takes up the mathematical side of machine design, the instruction being given by lectures, recitations, and drawing-room work. The student "lays out" mechanisms on the drawing board, analyzes the force, velocity, and energy transformations involved; proportions the members with consideration of strength, rigidity, and shop operations; and makes working drawings for the complete designs of machines.

The Department offers two of the optional groups that are open to seniors. The first includes instruction in the design of industrial structures and in the selection and arrangement of equipment for factories, power plants, etc. The second senior option offers instruction in ship design and construction, and includes both lectures and drafting-room work bearing on the theoretical and practical design of ships and also a discussion of the important features in the resistance, propulsion and powering of vessels.

3. DEPARTMENT OF MECHANICS OF ENGINEERING

Instruction is given in this department in theoretical and applied mechanics beginning with a course for sophomores in the fundamental principles of statics and kinetics, with application to mechanisms, followed by a comprehensive study of the mechanics of materials with their application to engineering design. An effort is made to teach students to think rather than to memorize. With this in view, the free-body method is used in the solution of problems involving forces, and students are required to work from fundamental definitions and principles rather than from formulas.

For juniors a course in hydraulics is given. A broad knowledge of the fundamental principles is deemed of more value than familiarity with special formulas or numerical coefficients. For seniors an elective course on hydraulic turbines

is offered. While the theory of turbines is outlined, stress is laid upon the practical side of the subject, the object being to make the course of definite value for those expecting to take up hydro-electric work. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

4. DEPARTMENT OF HEAT-POWER ENGINEERING

All students in Sibley College receive instruction in this department in their junior and senior years with the object of training them in the methods of solution of problems involved in the theory, design, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work of this department begins with lectures and recitations on the elements of heat-power engineering, including the study of the elementary thermodynamics of gas and vapors, theoretical and actual cycles, and steam engines. This is followed by a study of steam turbines, internal combustion engines, fuels and combustion, furnaces, boilers, draft apparatus, producers, heat transmission, condensers, feed-water heaters and other power-plant auxiliaries, the flow of gases and vapors, refrigeration, and air compressors.

In addition to taking these required courses, the student in his senior year may specialize in the design of steam engines or of internal combustion engines, by taking the lecture and drafting courses specially devoted to these subjects. He may also attend special lecture courses on steam turbines, steam boilers, gas manufacture, refrigeration, heating and ventilating, and motor car construction.

5. DEPARTMENT OF EXPERIMENTAL ENGINEERING

A. Mechanical Laboratory Division

Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses.

Throughout the junior and senior years the student receives instruction in the very completely equipped mechanical laboratories (described on page 9) not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but to teach him the best methods of research. Briefly, the courses include the use of computing machines; the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, etc.; tests of lubricants; fuel calorimetry; steam calorimetry; valve setting; tests of boilers, steam engines, turbines, pumps, heaters, condensers, injectors, and other steam apparatus; tests of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

B. Engineering Research Division

Engineering research by undergraduate students is carried on in this department under the supervision of a separate corps of specialists who devote their entire time to this work. Students who have shown proficiency in experimental engineering may have opportunity to conduct original investigations under expert guidance, and, as occasion offers, may assist in commercial tests, made at the University or elsewhere, of materials, prime movers, power plants, etc. The

equipment of every department is available for this work and the specialists in any department may be consulted.

In case the investigation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. Research, or Thesis, may be elected during the senior year by a limited number who have shown suitable adaptability for investigation. Arrangements for this work should be made with the department during the junior year, if possible.

This department will co-operate in every way to assist graduate students in mechanical, electrical, industrial, and mining engineering and will aid in providing apparatus and other facilities for graduate work.

6. DEPARTMENT OF ELECTRICAL ENGINEERING

Instruction in electrical engineering begins in the sophomore year, and is based on the required courses in Physics and Mathematics.

In the junior year the fundamental principles are emphasized and the subject developed by elaborating on these principles, rather than by the use of mathematical equations. Both direct and alternating current circuits and machinery are taken up. The theory is given in experimental lectures, and is applied to short design problems in the computing room. In the laboratory the student handles machinery, selects his own instruments and control apparatus, and makes the necessary tests to check the theoretical work.

For those senior students who are specializing in mechanical engineering a brief advanced laboratory and problem course is provided for the solution of such electrical problems as are encountered in general engineering practice.

The principal part of the work for the senior electrical students is given in a well balanced course in which advanced theory, problem work, design and laboratory practice combine to train the student along broad lines. The electrical laboratory being very flexible lends itself particularly to the development of resourcefulness and initiative on the part of the students. A moderate amount of special work is provided for by elective courses in electric traction, illumination, wireless telegraphy, etc., in which the classes are small and more time is devoted to these subjects than is possible in more general courses.

7. DEPARTMENT OF INDUSTRIAL ENGINEERING

Until recently the field of the mechanical engineer was a comparatively narrow one and comprised mainly the design, construction and operation of machinery. As industry has developed, however, many technically trained men have entered the fields of manufacturing, selling, and administration. This is a natural and increasing tendency since industrial development rests mainly upon a scientific basis. There are few lines of human activity to-day that are not connected in some way with applied science and this is particularly true of those lines known by the general term of engineering.

The success of the engineer in times past in meeting these commercial requirements, for which he had received no special training, was probably due to the method of attack characteristic of the engineer and to superior knowledge of the technical side of the work. But the commercial demands upon the engineer are now becoming so great that special training is necessary to equip him more completely for this larger field. This will appear more evident when it is con-

sidered that a large number of the graduates of mechanical engineering colleges go into the commercial side of engineering.

Therefore, in addition to training in the fundamental principles of engineering, every student in the regular courses in Sibley College is given some work in industrial organization and administration before he graduates; while in this department a more complete provision is made in the senior year for those who wish to specialize in the commercial side of engineering.

The work of the department begins in the junior year in which all students in the college are given a course of instruction in the basic principles of industrial organization. An optional group of studies is offered in the senior year for those who wish to specialize somewhat in this line of work, this option consisting of the engineering subjects required in all senior options, special courses of lectures and drawing room work in plant organization and arrangement, and a carefully selected group of economic studies treating of accounting, business law, industrial history and kindred subjects.

NONRESIDENT LECTURERS

Supplementing the regular course of instruction, lectures are delivered from time to time by nonresident specialists in the profession on various subjects relating to the many branches of mechanical and electrical engineering. The student may also attend the many public scientific lectures given in other departments of the University by nonresident lecturers.

COURSES OF STUDY

The following courses of study are offered:

1. The regular course leading to the degree of mechanical engineer and covering a period of four years (see page 24 for the first three years of the course). In the senior year of this course the student may specialize in:

Electrical Engineering (page 25)
Heat-Power Engineering,—Steam, Gas, etc. (page 25)
Structural and Plant Engineering (page 26)
Ship Design and Construction (page 26)
Industrial Engineering (page 27).

2. The special four year course in subjects relating to Mining Engineering (see page 28).

3. A five year course leading to the degree of Mechanical Engineer (see pages 29 and 30).

4. A six year course, in which the student is registered in the College of Arts and Sciences during his first three years of residence. The six year course leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Mechanical Engineer at the end of the sixth year (see page 31).

COURSES LEADING TO THE DEGREE OF MECHANICAL ENGINEER

1. THE REGULAR FOUR YEAR COURSE

In the regular four year course leading to the degree of Mechanical Engineer instruction is the same for all students during the first three years. In the fourth year, some opportunity is offered for specializing in the different branches of mechanical, electrical, and industrial engineering. The sequence of subjects and the time devoted to each course are given in the following tables. Detailed descriptions of the courses are given on pages 34 to 50, and the requirements for admission are stated on page 16.

NOTE. In referring to courses the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Industrial Engineering, I. From two and one-half to three hours per week of actual work in shops, laboratories, computing work, or drawing count as one hour credit in the schedule.

Freshman Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry and Calculus	34	6	6	6
Chemistry	35	1	0	6
Physics	34-35	3, 8	6	2
Drawing and Desc. Geom	40	D 1, 2	3	3
Foundry	39	S3	2 or 0	0 or 2
Forge	39	S4	0 or 1	1 or 0
Engineering Principles	43	P1	1	1 or 0
Military Drill	38	1	1	1

Sophomore Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	42	M5, 6	5	5
Physics, Recitations	35	9	2	0
Physics, Laboratory	35	14	2	2
Electrical Engineering	47	E 5	0	2
Chemistry	35	6	0 or 5	5 or 0
Kinematics	40	D6	0	2
Drawing	40	D5, 7	3	3
Materials	45	X6	3 or 0	0 or 3
Pattern Making	39	S7	3 or 0	0 or 3
Military Drill	38	1	1	1

Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Heat-Power Engineering	43	P10	3	3
Electrical Engineering	47	E14	2	2
Electrical Engineering	48	E15	2	2
Mechanical Laboratory	45	X10, 11	3	3
Machine Design—(a) Drawing	40	D10	2	2
(b) Lectures and Recitations	41	D16	3	3
Machine Work	39	S10	2	2
Industrial Organization	50	I 12	0	0
Hydraulics	43	M12	2	2

Senior Year

In the senior year the regular student must complete one of the options (A to E inclusive) which are given on the following pages. All these options have, in common, courses in Power Plant Design, Mechanical Laboratory, Electrical Engineering, and Economics; and under each option are lecture and drafting courses devoted to the special branch of engineering to which the option relates. In addition, provision is made in most of the options for electing, to a limited extent, courses given in any college of the University.

Option A. Electrical Engineering

This option is planned to give the thorough grounding in electrical engineering, required by engineers connected with the design, construction and operation of the electrical part of engineering properties.

The theoretical work in courses E 20 and E 21, along with the design and laboratory work, forms a well balanced course of study along broad lines. A moderate amount of special work along particular lines is provided for by the elective courses.

A considerable amount of mechanical engineering is also studied, so that the student is not limited in his outlook and in his choice of work after graduation.

Senior Electrical Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	44	P 20	3	3
Mechanical Laboratory	46	X 22	2	0
Economics	36	52	2	2
Electrical Machinery	48	E 20	2	2
Electrical Machinery	48	E 21	3	3
Electrical Design	48	E 22	2	2
Electrical Laboratory	48	E 28	4	4
Electives (or Thesis, X 32, page 47)	31-33		2	2

Option B. Heat-Power Engineering

The object of this option is to train men in the design of steam and internal combustion engines and auxiliary apparatus, and also in the design and arrangement of heat-power stations.

The special work of this option includes the theoretical and practical consideration of types, arrangements, general properties and details of steam and internal combustion engines, and their auxiliaries; the design of engine parts, valve gears, governors; balancing, determination of flywheel weights; and the selection and arrangement of machinery for steam and internal combustion power plants. This work is taught by lectures which are supplemented by a drafting course. In addition, among the elective courses, the student may include courses on Boiler Design, Steam Turbines, Gas Manufacture and Transmission, Refrigeration, Heating and Ventilating, and Motor Car Construction.

Senior Heat-Power Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	44	P 20	3	3
Mechanical Laboratory	46	X20, 21	3	3
Electrical Engineering	49	E 36	2 or 0	0 or 2
Electrical Engineering	49	E 37	0 or 2	2 or 0
Economics	36	52	2	2
Heat-Power Machinery Design	44	P 23	3	3
Drawing and Design	44	P 24	2	2
Gas Manuf. or Stm. Turbines	44	P28 or 25	0	2
Elective (or Thesis, X 32, page 47)	31-33		4	2

Option C. Structural and Plant Engineering

This option is intended for those who wish instruction in the general engineering problems involved in plant construction and equipment. It is intended to develop skill in the technical side of the planning of industrial plants rather than in detail design of machinery, and also to give the student a drill in the methods of attacking problems in plant design. The first part of the course that is a special feature of this option treats of the graphics of construction as applied to standard trusses and similar structures. This is followed by instruction in the theory and practice of footings, foundations, sidewalls and such other details as confront the engineer in planning industrial works. The second part of these courses is devoted to the selection and arrangement of machinery, using the knowledge of the characteristics of machines that the student has acquired in other courses to guide him in selecting the proper units. Each student is required to make a layout of some industrial plant, such as a power house, making the skeleton outline of the buildings, selecting and locating the machinery and carrying the design to the point usually required in a good preliminary design.

Among the optional hours the student may, if he desires, include the elective courses in Steam Boilers, Steam Turbines, Gas Power Machinery, Engineering Notes, Refrigeration, and Heating and Ventilating.

Senior Structural and Plant Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	44	P 20	3	3
Mechanical Laboratory	46	X 20, 21	3	3
Electrical Engineering	49	E 36	2 or 0	0 or 2
Electrical Engineering	49	E 30	0 or 2	2 or 0
Economics	36	52	2	2
General Engineering Design	41	D 22	2	2
Drawing and Design	41	D 23	3	3
Elective (or Thesis, X 32, p. 47)	31-33		4	4

Option D. Ship Design and Construction

The primary purpose of Option D is to train men who intend to enter ship

yards to make a life work of ship design and construction, but it may be taken profitably by men intending to follow other lines of mechanical engineering.

In this option the fundamental principles underlying the design of all the types of mercantile, war and pleasure vessels are discussed in detail. This is productive of problems in hydro-statics, hydro-dynamics and aero-dynamics, the solutions of which are deeply interesting, not only to the Naval Architect but to the Mechanical Engineer.

The materials used in the construction of vessels, their equipment, and their machinery, are taken up and their economic and structural values determined.

The speed and powering of vessels are fully dealt with along the lines indicated by the results derived from the latest experimental research, as well as those obtained from experience with actual vessels.

The different types of propelling machinery are critically examined from the standpoint of their adaptability in the three classes of vessels referred to above.

Specifications, contracts and the organization of shipyards, docks, and engineering shops, form the subjects of interesting and useful discussions.

Senior Ship Design and Construction Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	44	P20	3	3
Mechanical Laboratory	46	X 20, 21	3	3
Electrical Engineering	49	E36	2 or 0	0 or 2
		E37	0 or 2	2 or 0
Economics	36	52	2	2
Ship Design	41	D25	3	3
Speed and Power of Ships	42	D26	0	2
Drawing and Computation	42	D27	3	3
Specifications, Contracts, etc	42	D28	2	0
Elective	31-33		0	2

Option E. Industrial Engineering

This option is intended for those who wish to enter the commercial side of engineering or who are particularly interested in industrial organization and administration. In the special courses relating to this option are discussed the modern time-keeping and cost-finding systems, methods of planning work and insuring production, time and motion studies, purchasing, problems in administration, plant locating, heating, lighting, powering, safety engineering, fire protection and similar subjects. In the drafting and designing course the graphical work includes the application of these fundamental principles to planning industrial enterprises. The time allotted to economics will be devoted to such courses as accounting, business law, government control of industry and financial history. Students who wish to elect this option must receive credit for Elementary Economics 52, or its equivalent, before the senior year, since this is a prerequisite for some of the courses required in the option. Students expecting to elect this option are also advised to read for preparation as much industrial history and kindred subjects as possible.

Senior Industrial Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	44	P 20	3	3
Mechanical Laboratory	46	X20, 21	3	3
Electrical Engineering	49	E36	2 or 0	0 or 2
Electrical Engineering	49	E37	0 or 2	2 or 0
Industrial Administration	50	I20	2	2
Drawing and Design	50	I22	3	3
Safety Eng'g and Fire Protection	50	I23	0	2
Accounting		58 a	3	0
Electives	31-33		0	3

2. A FOUR YEAR COURSE IN SUBJECTS RELATED TO MINING ENGINEERING

Students who have satisfied the requirements for admission as freshmen in the four year course may substitute in place of the regular course given on pages 24 to 28, the following special four year schedule of subjects relating to Mining Enginecring and leading to the degree of Mechanical Engineer.

NOTE. In referring to courses, the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; From two and one-half to three hours per week of actual work in shops, laboratories, computing work, or drawing count as one hour credit.

Freshman Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry and Calculus	34	6	6	6
Chemistry, Introductory Inorganic	35	Chem. 1	6	0
Chemistry, Qualitative Analysis	36	" 7	0	6
Physics	34-35	Phys. 2, 7	5	3
Forge	39	S4	0	2
Military Drill	38	1	1	1

Sophomore Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	42	M5, 6	5	5
Chemistry, Quantitative Analysis	36	Chem. 12	0	6
Physics Laboratory	35	Phys. 14	4	0
Crystallography	36	Geol. 12	3	0
Mineralogy	37	Geol. 13	0	3
Dynamic and Historic Geology	36-37	" 1, 21	3	3
Drawing	40	D1, 2	3	3
Military Drill	38	1	1	1

Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Kinematics	40	D6	0	2
Drawing	40	D5, 7	3	3
Electrical Engineering	47	E5	0	2
Heat-Power Engineering	43	P10	3	3
Metallurgy of Iron and Steel	45	X 6	3	0
General Econ. Geology	37	Geol. 32	3	3
Mining of Mineral Deposits	37	" 34	3	3
Surveying		C.E.10, 11	3	4
Summer Field Work in Mining	37	Geol. 39	3	0

Senior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Assaying	36	Chem. 18	3	0
Blowpipe Determination of Minerals	37	Geol. 14	1	0
Machine Design—				
(a) Drawing	40	D10	2	2
(b) Lectures and Recitations	41	D16	3	3
Mining Methods and Design	42	D39	2	2
Mechanical Laboratory	45	X10, 11	3	3
Hydraulics	43	M12	0	2
Examination of Mineral Deposits	37	Geol. 33	0	2
Electrical Engineering	47	E14	2	2
Electrical Engineering	47	E15	2	2
Machine Work	39	S10	0	2

3. REGULAR FIVE YEAR COURSE

The requirements for admission to the five year course leading to the degree of Mechanical Engineer are given on page 16.

The optional hours in the five year course make it possible for the student either to elect subjects of a liberal or cultural value, or to specialize to a limited extent in some branch of science in which he may be particularly interested, such as Economics, Chemistry, Physics and Geology; or the student may include some of the elementary courses in Mining or Civil Engineering or in Architecture.

The outline of the first two years gives the subjects which must be taken in order that the student may enter the third year properly prepared for the engineering work. It is essential that the student should follow the sequence of subjects as given in this outline, for otherwise it may be impossible for him to complete the requirements for the degree by the end of the fifth year.*

Students in this course are required to carry at least 17 credit hours a term, exclusive of drill. First year students are limited to a maximum of 19 hours a term, and second year men to 20 hours.

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*A student who meets the requirements for entrance to the College of Arts and Sciences may be able to secure the A.B. degree at the end of four years, and the M.E. degree at the end of the fifth year. During the first three years the student would be registered in the College of Arts and Sciences but would pursue a course of studies approved by the Sibley College Adviser for five year students. The last two years would be spent in Sibley College.

NOTE. In referring to courses of instruction the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X. For description of courses given by other colleges, see the announcements of those colleges. From two and one-half to three hours per week of actual work in shops, laboratories, or drawing count as one hour credit in the schedule.

First Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
English	38	I	4	4
Advanced Algebra†	34	2	5	0
Solid Geometry†	34	I	0	3
Trigonometry†	34	3	0	3
Chemistry	35	I	0	6
Engineering Principles	43	P1	1	0
Forge Shop	39	S4	0	1
Foundry	39	S3	2	0
Elective in Arts and Sciences	31		5	0
Military Drill	38	I	1	1

Second Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytical Geometry and Calculus	34	6	6	6
Chemistry	35	6	5	0
Physics	34	3	0	6
Drawing	40	D1, 2	3	3
Elective in Arts and Sciences	31-32		3	2
Military Drill	38	I	1	1

Third Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	42	M5, 6	5	5
Physics, Recitations	35	8, 9	2	2
Physics, Laboratory	35	14	2	2
Electrical Engineering	47	E5	0	2
Kinematics	40	D6	0	2
Drawing	40	D5, 7	3	3
Materials	45	X6	3	0
Pattern Making	39	S7	0	3
Elective in Arts	31-32		3	0

Fourth and Fifth Years

The fourth and fifth years are identical with the third and fourth years of the regular four year course (see pages 24 to 28).

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†If credited in this subject at the time of admission, an equivalent number of hours may be elected in some other subject.

4. FIVE YEAR COURSE SPECIALIZING IN MINING ENGINEERING

The requirements for admission to the five year course are given on page 16. This five year course leads to the degree of Mechanical Engineer, and it is possible for those pursuing it to complete not only the subjects listed in the four year course relating to Mining Engineering but also to take substantially all of the additional subjects given in the regular four year course in Mechanical Engineering.

5. A SIX YEAR COURSE LEADING TO THE DEGREES OF A.B. AND M.E.

A student in the College of Arts and Sciences who has satisfied at least six terms of residence, no one of them under the provisions of paragraph (2) of the requirements for the A.B. degree, may with the permission of the faculties concerned be registered both in the College of Arts and Sciences and also in any other college of Cornell University. This provision enables a student who so desires, to obtain the degree of A.B. from the College of Arts and Sciences at the end of four years, and the degree of M.E. from Sibley College at the end of six years.* Advice and assistance in arranging such a course may be had by applying to the Dean of Sibley College and the Dean of the College of Arts and Sciences.

In order to make it possible to secure the M.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects (page 24) before the beginning of his fourth year, and must complete the list of sophomore subjects (page 24) before the beginning of his fifth year.

ELECTIVES

Students having the necessary preparation and having the approval of their class adviser may take any of the subjects in the following lists. The choice of studies is not limited to those here listed; the student may, with the approval of his class adviser and of the department concerned, take any subject in any department in the University. For detailed information regarding these elective subjects see the announcements of the Departments in which they are given.

A. Elective Subjects Open to Freshmen

German, French, Spanish, Greek, Latin, English, Roman History, English History, History of Civilization, Bibliography, Music, Biology, Botany, Entomology, Zoology, Physiology, Photography, Agriculture, Law, Geology, Mining, Public Speaking, Surveying, Freehand Drawing and the freshman engineering subjects given on page 24.

B. General Electives

In addition to the foregoing list of subjects open to freshmen, the following may be taken in any year, except where the year, or prerequisite, is given in the parenthesis immediately following the subject.

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*See footnote on p. 29 regarding the possibility, under certain conditions, of securing the two degrees in five years.

Course	No. Course	Hours 1st Term	Hours 2d Term
Differential Equations (Calculus)	41	3	3
Surveying (Trigonometry)	C.E.12	0	2
Spec. and Contracts (3 or 4)	C.E.90	2 or 0	0 or 2
Assaying (Chem. 6)	Chem. 18	3	0
Adv. Quant. Anal. (Chem. 6)	Chem. 14	1–3	1–3
Adv. Quant. Anal. Lectures (Chem. 6)	Chem. 15	2	0
Qual. and Quant. Gas Anal. (Chem. 6)	Chem. 19	0–2	2–0
Tech. Gas Anal. (Chem. 6)	Chem. 20	0–2	2–0
Chemistry of Gases (Chem. 6)	Chem. 49	0	1
Photometry and Illumination (Physics 14)	Phys. 26	1–4	1–4
Photometry and Illumination (Physics 14)	Phys. 43	2	0
Photography (2)	Phys. 18	2 or 0	0 or 2
Elementary and Historic Geology	Geol. 1, 21	3	3
Bldg. Stone and Clay Products	Geol. 30	2	0
Engineering Geology	Geol. 31	3	3
Mineralogy (Chem. 1)	Geol. 11	0 or 3	3 or 0
Mining of Mineral Deposits	Geol. 34	2	2
Economics, Elementary (2)	52 or 51	2 or 3	2 or 3

Economics: Accounting, Business Law, Corporations and Trusts, Money and Banking, Labor Problems, Railway Transportation, Public Utilities, Government Control of Industries, etc. (Econ. 51 or 52, is required for most of these.)

Aesthetics, Archeology, Astronomy, Ethics, Philosophy, Logic, Psychology, Military Science, and advanced courses in subjects given in List A, above.

C. Technical Electives for Seniors Only

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Thesis	47	X32	0–8	8–0
Steam Boiler Design	45	P30	2	0
Steam Turbines	44	P25	0	2
Gas Manuf. and Distribution	44	P28	0	2
Gas Power Machinery	44	P29	2	0
Advanced Heat-Power Engineering	45	P40	1–3	1–3
Refrigeration	45	P31	0	2
Motor Car Construction	45	P32	0	2
Heating and Ventilating	45	P33	0	2
Engineering Research	46	X30	1–3	1–3
Power Plant Testing	46	X31	1–3	1–3
Engineering Notes	41	D24	0	2
Speed and Power of Ships	42	D26	0	2
Advanced Designing	42	D40	1–3	1–3
Industrial Administration	50	I20	2	2
Safety Eng'g and Fire Protection	50	I23	0	2
Advanced Industrial Engineering	50	I40	1–3	1–3
Central Stations	48	E 23	0	2
Elem. of Elect. Ry. Pract.	48	E25	0	2

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Wireless Telegraphy	48	E27	0	2
Special Elect. Eng. Problems.....	49	E33	1–3	1–3
Engineering Mathematics	49	E 30	2	2
Hydraulic Turbines	43	M21	2	0
Railway Cons. and Maintenance ..		C.E.63	0	2
Concrete Construction		C.E.77	0–3	3–0
Alternating Currents		Phys. 33	2	0
Electrical Lab. Practice		Phys. 34	3 or 0	0 or 3
Sibley Journal Credit	47	X40	0 to 2	0 to 2

COURSES OF INSTRUCTION

SUBJECTS GIVEN IN THE COLLEGE OF ARTS AND SCIENCES*

Mathematics

Examinations for the removal of conditions in mathematics 1–8 are held in September just before registration. Similar examinations are held in April for the removal of conditions incurred at the end of the first term. For further information, apply to the Department.

1. **Solid Geometry.** Repeated in second term, credit three hours. First term, T Th S, 10; second term, M W F, 10. Professor Tanner in charge.

Open to all students, but designed especially for those who have entered with the minor requirements in mathematics and are preparing: (a) to teach mathematics in the secondary schools; (b) to take up engineering work later in the course; (c) to specialize in chemistry or physics.

2. **Advanced Algebra.** Repeated in second term, credit five hours. Daily exc. S, 9. Professor Tanner in charge.

Open to all students, but designed especially for those mentioned under course 1.

2 (E). **Advanced Algebra.** First term, credit three hours. M W F, 9.

Open to students who have met the entrance requirements in intermediate algebra. The work covered is the equivalent of that required in this subject for admission to courses 6. Professor Tanner in charge.

3. **Plane Trigonometry.** Repeated in second term, credit three hours. First term, M W F, 10; second term, T Th S, 10. Professor Tanner in charge.

Open to all students, but designed especially for those mentioned under course 1.

6. **Analytic Geometry and Calculus.** Throughout the year, credit 6 hours each term. Twenty-four sections daily. Under the direction of Professor TANNER. The first term's work in this course is also offered in the second term and the second term's work in the first term of the following year.

Physics

2. **Introductory Experimental Physics.** Repeated in second term, credit five hours. Three lectures and two class-room periods a week. Lectures: T Th S, 9; M W F, 11, Rockefeller A. Professors NICHOLS, MERRITT, and SHEARER, and Assistant Professor GIBBS. Class-room work: Assistant Professor GIBBS and Instructors. Hours to be arranged.

Entrance physics is not accepted as an equivalent of this course.

3. **Introductory Experimental Physics.** Repeated in second term, credit six hours. Prerequisite courses Advanced Algebra and Trigonometry. Three lectures and three recitations a week. Lectures: Professors NICHOLS, MERRITT and SHEARER, and Assistant Professor GIBBS. Class-room work: Assistant Professor GIBBS and Messrs. BAILEY, BIDWELL, GRANTHAM, KING, MORATH, and ROGERS.

Entrance Physics will not be accepted as an equivalent of this course.

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*Only those subjects that are included in the regular four year, five year, and mining courses in Mechanical Engineering are given. For the other subjects see the Announcement of the College of Arts and Sciences.

7. **General Physics.** Primarily for students in civil engineering. Classroom work. Repeated in second term, credit three hours. Prerequisite course 2 Messrs. MURDOCK and MALLORY. Hours to be arranged.

8. **General Physics.** Theory. First term, eight sections; repeated in second term, one section; credit two hours. Prerequisite courses Math. 6 and Phys. 3. Assistant Professor RICHTMYER and Messrs. BIDWELL, BROWN, GERMANN, PIDGEON, and SCHELLENG. Two recitations per week as assigned, Rockefeller as assigned.

Textbook work in statics, dynamics, properties of matter, electrostatics, and magnetism. Two hours of Physics 14 must be taken in connection with Physics 8

9. **General Physics.** Theory. Second term, eight sections; repeated in first term of following year, one section; credit two hours. Prerequisite Physics 8 and the first term of Physics 14. Instructing staff as in Physics 8. Two recitations per week as assigned, Rockefeller as assigned.

Textbook work. A continuation of Physics 8. Current electricity, heat (including thermometry, expansion, calorimetry, radiation, and conduction, properties of vapors, and an introduction to the kinetic theory of gases), and thermodynamics. Two hours of Physics 14 must be taken with Physics 9.

14. **Physical Experiments.** Throughout the year, credit two hours a term. One laboratory period per week. Must be accompanied by Phys. 8 and 9. Must be preceded by Math. 6 and either by Phys. 3, or by Phys. 2 and 7 and 2 hours of Phys. 10. Assistant Professor RICHTMYER, and Messrs. BIDWELL, BROWN, GERMANN, PIDGEON, SCHELLENG, SIVIAN, KOLLER, and MOORE. Rockefeller 250–257 as assigned.

Physical measurements, properties of matter, mechanics, heat, light, sound, magnetism, and electricity; the adjustment and use of instruments of precision. Results and errors are carefully discussed. Two hours of Physics 14 must be taken with Physics 8 and two hours with Physics 9.

Chemistry

1. **Introductory Inorganic Chemistry.** Lectures, recitations and laboratory. Second term, credit six hours. Not open to Sibley students in the first term.

1a. Lectures, T Th S, 11, Professor DENNIS and Mr. MCCOY; T Th S, 12, Professor BROWNE and Mr. MCCOY.

1b. Recitations (one hour a week to be arranged). Laboratory (two 2½-hour periods per week); Second term, M F, 2–4.30; T Th, 2–4.30; W, 2–4.30; and S, 8–10.30; M W, 8–10.30. Professors DENNIS and BROWNE, Dr. WELSH, and Messrs. MCKINNEY, TANNER, FOGELSONG, DANN, STRICKER, PASHKOW and WIGHTMAN.

Entrance credit in chemistry does not carry with it University credit in course 1. If a student entering the University from a preparatory school desires credit in course 1 he must pass an examination set by the Department of Chemistry. This examination is held both in New York City and in Ithaca on the same day in September as the entrance examination. University credit in course 1 that is obtained by passing this examination does not carry with it entrance credit in chemistry.

Examinations for those who were unavoidably absent from the final examination in course 1 will be held at 2 p. m. on the day before instruction begins in the fall.

6. **Qualitative and Quantitative Analysis.** Repeated in second term, credit five hours. Prerequisite course 1. Dr. RHODES, and Messrs. GILCHRIST, LOUDER, STERN and HOCK. Lectures and recitations: T Th., 12 Laboratory sections: M W F, 2–5; T Th S, 8–11; T Th S, 9–12.

Qualitative work: the properties and reactions of the common elements and acids and their detection in various liquid and solid mixtures.

Quantitative work: the preparation and use of volumetric solutions and work in elementary gravimetric analysis.

Examinations for those who were unavoidably absent from the final examination in course 6 will be held at 2 p. m. on the day before instruction begins in the fall.

7. **Qualitative Analysis.** (Mining). Repeated in second term, credit six hours. Prerequisite course 1. Dr. RHODES, and Messrs. STUPP and NELSON. Lectures: T Th, 9, Rockefeller 155. Laboratory: first term, M W, 2–5, S, 8–12; second term, T Th, 2–5, S, 8–12.

The properties and reactions of the common elements, and of the common inorganic and organic acids, also the qualitative analysis of a number of solutions and solid mixtures.

12. **Quantitative Analysis, Elementary Course.** (Mining). Repeated in second term, credit six hours. Prerequisite course 6 (or preferably 7). Assistant Professor LUNDELL and Messrs. KOLLER, JENKS, and JOHNSON. Lectures, first term. T Th, 9; second term, T Th, 8.

Laboratory sections: M T W, 2–5.30; W Th F, 2–5.30; T Th, 10–1, S, 8–1.

The preparation and standardization of various volumetric solutions and their use in analyzing a variety of substances; gravimetric methods.

18. **Assaying.** (Mining). First term, credit three hours. Prerequisite course 6 (or 7 and 12), and if possible a course in mineralogy. Assistant Professor LUNDELL and Mr. GILCHRIST. Lecture F, 10. Place to be announced. Laboratory, M W, 2–5.

Lectures on the theory and practice of the scorification and crucible assay, and on the metallurgy of copper, lead, zinc, silver, and gold. In the laboratory, practice is given in assay of zinc, lead, copper, gold, and silver ores, mattes, and bullion. Designed for students that are specializing in chemistry and as an elective for students in mechanical and civil engineering.

Economics

52. **Elementary Economics.** Throughout the year. Credit two hours a term. One lecture and one recitation each week. Lectures, M, 9 or T, 9. Recitations, W Th F, 10. Mr. CAMPBELL.

Geology

1. **Elementary Geology.** Required of mining students. Repeated in second term, credit three hours. Professor RIES and Messrs. BEAN, ELSTON and GREENLAND. Lectures, first term, T Th, 11, Sibley Dome; second term, T Th, 9, Sibley Dome. Laboratory period, M T W Th F afternoon or S morning. One all-day excursion required.

Planned to give beginners the fundamental principles of this branch of science with special attention to dynamic and structural geology. Those desiring additional work in geology are advised to take one or more of the following courses: 2, 11, 21, 32.

12. **Crystallography.** Required of mining students. Repeated in second term, credit three hours; if taken after course 11, credit two hours. Prerequisites

Chemistry 6 or 7, and Physics 1. Professor GILL and Mr. SMITH. Lectures, T Th, 8, McGraw, Geological Lecture Room. Laboratory hours to be arranged.

The object of this course is to furnish a fundamental knowledge of the characteristics of crystallized matter as a basis for further study of crystalline substances in mineralogy, chemistry, or physics.

13. **Mineralogy.** Required of mining students. Second term, credit three hours; if taken after course 11, credit two hours. Prerequisite course 12. Hours to be arranged. McGraw, Geological Lecture Room. Professor GILL.

For students wishing to become acquainted with the commoner minerals and with the scientific and practical problems which they suggest.

14. **Blowpipe Determination of Minerals.** Required of mining students. First term, credit one hour. Prerequisite course 11 or 13 and Chemistry 6 or 7. Professor GILL. One laboratory period Saturday morning, McGraw, Mineralogical Laboratory.

21. **Historic Geology.** Required of mining students. Second term, credit three hours. Prerequsite course 1 or its equivalent. A course in invertebrate zoology is also desirable. Professor HARRIS. Lectures, T Th, 11, McGraw, Geological Lecture Room. Laboratory hour to be arranged.

An elementary review of the geologic history of the earth and its inhabitants; covering, accordingly, with course 1 the major topics usually included under Elementary Geology. Frequent field excursions take the place of laboratory work as soon as weather permits. One or two all-day excursions to Rochester Gorge or Union Springs; several half-day excursions by boat on Cayuga Lake.

32. **General Economic Geology.** Required of mining students. Throughout the year, credit three hours a term. Prerequisite courses 1 and 11, or their equivalent. Professor RIES and Assistant Professor SOMERS. Lectures, M W, 11 Laboratory, T, 2 or Th, 2, McGraw.

The origin, nature, distribution, and uses of the non-metallic and metallic products of the earth's crust. First term, the non-metallics, including coal, oil, gas, clays, salt, fertilizers, etc. Second term, the metallic products, including the ores of iron, copper, lead, zinc, gold, silver, etc. Students may take lectures without laboratory only by special permission. Field trips may be substituted for a portion of the laboratory work.

33. **Field Examination of Mineral Deposits.** Required of mining students. Second term, credit two hours. Prerequisite courses 31 or 32. Assistant Professor SOMERS. T Th, 11, McGraw.

Designed to acquaint the student with the methods used for examining deposits of economic value, with a view to determining their extent and character.

34. **Mining of Mineral Deposits.** Required of mining students. Two or three hours a term as the student desires to elect. Assistant Professor SOMERS. Lectures, M W F, 9, McGraw.

A general course describing the methods of mining deposits of economically valuable materials, and the relation between the origin and structure of the deposits and the methods used.

39. **Field Work in Mining Geology.** Required of mining students. Credit three hours. Professor RIES and Assistant Professor SOMERS.

In the summer following the junior year, students taking the courses in mining are required to devote about 8 weeks to field work in a mining district and submit a written report in standard form of the work done and observations made.

English

1. **Introductory Course in English.** Required of Five Year students. Throughout the year, credit four hours a term. Students who have not taken the course in the first term may enter in the second term in sections provided for them. Open only to underclassmen who have satisfied the entrance requirement in English. Freshmen who are candidates for the degree of Bachelor of Arts will ordinarily take course 3, and may not enroll in course 1 except with the consent of the head of the department. Assistant Professors ADAMS and MONROE; Drs. BAILEY and GILBERT; Messrs. BALDWIN, HEBEL, BOULTER, BUNDY, LAPPIN, ———, and ———. Twenty-eight sections at the following hours: T W Th F, 8. 10, 11, 12, and M T Th F, 2. Rooms to be announced.

A study of representative works in English literature, including four plays of Shakespeare, two modern novels, selected essays, and poems of Milton and Tennyson. Practice in composition in connection with the reading, with incidental study of the principles of writing. Registration in the course is in charge of Dr. BAILEY.

Students who elect English 1 must apply at Goldwin Smith A on Monday, Tuesday, or Wednesday of registration week for assignment to sections.

Military Science and Tactics

1. **Practical and Theoretical Military Training.** Throughout the year, credit one hour a term. M W F, 4.45, Drill Hall.

Every male student, a candidate for a baccalaureate degree, who is required to take five, six, seven, eight or more terms in residence, must take, in addition to the scholastic requirements for the degree, one, two, three, or four terms respectively of three hours a week in the Department of Military Science and Tactics, except as provided below.

A holder of a college degree is exempt from the entire requirement. A student who is admitted from another college to take at Cornell four or less terms for his degree is exempt from the entire requirement. A student excused by the Military Department from one or more terms of required drill must substitute therefor a corresponding number of terms of Physical Training. A student may be permanently excused from Drill or Gymnasium by the Medical Adviser, or by the Committee on Excuses from Physical Training and Military Science, and in such cases the student shall not be required to make substitution for this work. No credit will be given for Drill to any student who has received his instruction in the subject in an institution other than that of college rank.

The requirements in Military Science must be completed in the first terms of residence; otherwise the student will not be permitted to register again in the University without the consent of the University Faculty.

The aim of the Department is to prepare graduates for becoming officers of a reserve or volunteer force. The students are organized into companies and a Band for a course of training prescribed by the War-Department.

This course includes physical training, rifle shooting, military drill, and the application of fundamental principles of modern infantry tactics. During the

second year qualified men may be given optional instruction in units specializing in signal corps, military engineering, and machine gun training. The Band is both the cadet and university band and students regularly enrolled in the Department may be assigned thereto for training instead of to a company.

2. **Elective Military Training.** Throughout the year, credit two hours a term. M W F, 4.45 Drill Hall. Prerequisite course 1 or its equivalent.

An advanced course covering practically and theoretically the duties of officers and non-commissioned officers with the units represented in the Department.

3. **Tactics.** First term, credit one hour. M F or S, 12. Drill Hall. A course in the technique of modern tactics, consisting of lectures, map problems, and tactical walks. Professor of Military Science and Tactics.

4. **Military Science and Tactics.** Second term, credit two hours. T Th, 12. Drill Hall. Prerequisite course 3.

An advanced lecture course dealing with the duties of officers in connection with the administration and control of their commands. Professor of Military Science and Tactics.

Physical Training

1. **Physical Training.** Required of Freshmen excused from drill. Throughout the year, three periods weekly.

2. **Physical Training.** Required of Sophomores excused from drill. Throughout the year, three periods weekly.

3. **Boxing and Wrestling.** Daily except Saturday. Messrs. O'CONNELL and SHEVLIN. A special fee of $5 per term is charged for instruction in each branch.

For the required work in Physical Training see the Gymnasium Handbook issued in the department.

SUBJECTS GIVEN IN SIBLEY COLLEGE

From two and one-half to three hours in shops, laboratories, computation work, or drawing count as one credit hour in the schedule.

DEPARTMENT OF MACHINE CONSTRUCTION

S. 3. **Foundry Work.** Freshmen. Either term, credit two hours. Five hours of work a week. Moulding, core making, mixing, and casting of metals, use of moulding machines. Demonstration of large work and production in quantities. Messrs. VANDERHOEF and EVANS.

S. 4. **Forge Work.** Freshmen. Either term, credit one hour. Two and one-half hours of work a week. Forging, welding, tool dressing, tempering, etc., together with demonstrations in the production of drop forgings. Messrs. HEAD and BROOKS.

S. 7. **Pattern Making.** Sophomores. Either term, credit three hours. Seven and one-half hours of work a week. Prerequisite course S, 3. Use of hand and machine tools for wood working, followed by graded instruction in pattern making, construction of core boxes, etc. Messrs. HOOPER, BUSH, and PRICE.

S. 10. **Machine Work.** Juniors. Throughout the year, two hours credit a term. Six hours of work a week. Prerequisite courses S. 3, 4, and 7. Use of measuring instruments, hand and machine tools, fitting, and assembling. Operation and use of jigs and other manufacturing fixtures. Operation of semi-auto-

matic and automatic machines and the illustration of manufacturing methods generally. Professor WELLS, and Messrs. HOWE, BUCK, and BLOCK.

DEPARTMENT OF MACHINE DESIGN

D. 1. **Drawing.** Required of freshmen. First term, credit three hours. Eight hours of work a week. Lettering (proficiency in at least one style of simple lettering); mechanical drawing; working drawings, including conventions, standards, etc., following the best commercial practice. Assistant Professor HAM, and Messrs. ARMBRUSTER, DIEDERICHS, HARRINGTON, HOUGH, MORDOFF, and TAYLOR.

D. 2. **Descriptive Geometry.** Required of freshmen. Second term, credit three hours. Eight hours of work a week. Lecture and drawing periods. The course includes points, lines, planes, solids, tangents, intersections, and developments, with solutions in all quadrants; isometric projections, with practical applications. Assistant Professor HAM and Instructors as in D 1.

D. 3. **Drawing.** For students registered for the degree of Bachelor of Chemistry. First term, credit three hours. Eight hours of drawing a week. Lettering, mechanical drawing, working drawings, including conventions, standards, etc. Similar to Course D. 1 but modified to suit the needs of students registered as above. Assistant Professor HAM and Messrs. HARRINGTON, HOUGH, and TAYLOR.

D. 5. **Machine Drawing.** Sophomores. First term, credit three hours. Eight hours of drawing a week. Prerequisite courses D. 1 and 2. Application of the work of course D. 1 to machine drawing in connection with empirical designing; proportioning of machine details as fixed by common practice rather than by mathematical theory; making and using standard data sheets; making of assembly drawings. Assistant Professor HAYES and Messrs. ANDRAE, FENTON, CLARK and WORN.

D. 6. **Kinematics.** Sophomores. Second term, credit two hours. Prerequisite courses D. 1 and 2, and must be taken with course D. 7. Two recitations a week on the theory of mechanisms, instant centers, cams, gears, linkages, velocity and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. ANDRAE, FENTON, CLARK and WORN.

D. 7. **Kinematic Drawing.** Sophomores. Second term, credit three hours. Eight hours of drawing a week. Prerequisite courses D. 1 and 2, and must be taken with course D. 6. Drawing board application of the work in course D. 6. Solution of mechanisms by means of instant centers, the designing of cams, gears, linkages, etc., drawing of velocity and acceleration diagrams, etc. Assistant Professor HAYES, and Messrs. ANDRAE, FENTON, CLARK and WORN.

D. 10. **Drawing and Design.** Juniors. Throughout the year, credit two hours each term. Six hours of drawing a week. Prerequisite courses D. 5. D. 6, D. 7, M. 5 and 6, and must be taken with course D. 16. Drawing room problems in elementary machine design illustrating the work as given in D. 16. The student for the first time undertakes the design of a complete machine, laying out the general outlines, proportioning the details theoretically, and modifying his results by practical considerations. All computations necessary for the complete design must be carefully and systematically made. Working drawings of the most important details and a finished assembly drawing are

completed. Professors KIMBALL and ALBERT, and Messrs. BRADFORD, GARNER, PARMLEY and ROGERS.

D. 16. **Machine Design.** Juniors. Throughout the year, credit three hours a term. One lecture and two recitations a week. Prerequisite courses D. 5, 6, 7, M. 5 and 6, and must be taken with D. 10. Selection of mechanism for specified work and study of practical considerations involved. Analysis of energy and force problems in machines. Determination of driving devices as based on work to be done. Proportioning of detail parts as dictated by stress and practical considerations. Applications of the laws of mechanics and kinematics to the design of machines, and a discussion of empirical design and modifications due to practical considerations. Professors KIMBALL and ALBERT, and Messrs. BRADFORD, GARNER, PARMLEY and ROGERS.

D. 22. **General Engineering Design.** Required of seniors in Option C. Throughout the year, credit two hours a term. Lectures. Prerequisite courses D. 10, D. 16, and P. 10, and must be taken with D. 23. For students who do not wish to specialize in any particular branch of engineering but wish to get a general knowledge of mechanical engineering design and construction. The work of the first term consists of a discussion of the problems met with in the design, construction, and equipment of mills, factories, etc., including foundations, walls, floors, trusses, roofs, and mill construction work in general; powering of factories, motor driving of machine tools, etc. In the second term this work is applied to the outline design of a complete power house, including the location of plant; track and wharf facilities; selecting and locating boilers and engines; coal storage, coal and ash handling equipment; selection and arrangement of condensers, pumps, steam piping, etc. Assistant Professor LEE and Mr. TOWNSEND.

D. 23. **Drawing and Design.** Nine hours of work a week throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16 and P. 10, and may only be taken in connection with D. 22. Design and drawing of various classes of work illustrating the principles discussed in D. 22. Graphical analysis of stresses in trusses and other structures. In the second term, drawings are made for the complete outline design of a power house as discussed under course 22. Assistant Professor LEE and Mr. TOWNSEND.

D. 24. **Engineering Notes.** Elective for seniors. Second term, credit two hours. Prerequisite courses D. 10 and 16. Lectures on some practical problems encountered in the everyday work of the engineer, solutions of these being arrived at by a reference to actual experience in different branches of engineering. Problems illustrative of the application, in combination, of the three qualifications of the successful engineer, i. e., theory, practice and common-sense. Professor MCDERMOTT.

D. 25. **Ship Design.** Required of seniors in Option D. Lectures throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16. The lectures of the first term deal with the conception and derivation of the elements of form; hydro-static principles underlying the design of vessels; methods of computing the geometrical quantities—displacement, centers of buoyancy, metacenters, etc.; tonnage, reserve buoyancy and freeboard; materials used in the construction of vessels; the structural elements of mercantile and naval ships, their functions and inter-relations; construction rules of the leading Classification Bureaus and Navy Departments.

The lectures of the second term deal with the weights, strength and stability of vessels and the methods which are used in practice in estimating these quantities and qualities. Safety of life at sea is given the fullest consideration. Professor McDERMOTT.

D. 26. **Speed and Power of Ships.** Required of seniors in Option D. Second term, credit two hours. Prerequisites D. 10 and 16. Lectures. The fundamental hydro- and aero-dynamics underlying the study of the resistance of vessels—floating, submarine and aerial—and of the different propelling agents, chiefly that of the screw-propeller. An analytical discussion of the experiments made on models of ships and propellers in the experimental tanks and laboratories in the United States and abroad, and from the results obtained practical methods and formulas are derived for estimating the resistance and horse-power required for vessels of all types, as also, the most suitable dimensions of propeller. The different types of propelling machinery—steam (reciprocating and turbine), electrical, internal combustion, and their combinations; their mechanical, space and weight, efficiencies; and their respective merits reviewed from the propulsive and commercial standpoints. Steam boilers of the firetube and watertube types; their characteristics and suitability for mercantile and war vessels. Professor McDERMOTT.

D. 27. **Design and Drawing.** Required of seniors in Option D. Throughout the year, credit three hours a term. Must be accompanied by D. 25. Delineation of the "lines" of a vessel with selected elements of form. Drawing of "scantling" section according to the rules of the American Bureau of Shipping. Computations of geometrical quantities, strength and stability Estimates of horse-power, weight of vessels and machinery. Professor McDERMOTT.

D. 28. **Specifications, Contracts, etc.** Required of seniors in Option D. First term, credit two hours. Prerequisite courses D. 10 and 16. Lectures. Discussion of the headings and principal points to be observed in drawing up specifications and contracts for vessels, their equipment and machinery. Financial, technical and operative organization of shipyards. Cost systems and methods leading to efficient production. Professor McDERMOTT.

D. 39. **Mining Methods and Design.** Required of all seniors in mining; not open to others. Six hours per week throughout the year, credit two hours per term. Lectures, reading and drafting as assigned. The course includes the design of machinery for extracting and concentrating ores, the design of pumps, timbering, etc. Students in this course are divided into groups, each of which undertakes some comprehensive portion of the development of a mining property, while a seminar keeps these groups in touch with each other. Professor KIMBALL.

D. 40. **Advanced Designing.** For graduates who have had the equivalent of D. 22 and D. 23, or of D. 25, 26, and 27. Advanced work in original design as arranged with Professors KIMBALL, McDERMOTT, and ALBERT.

DEPARTMENT OF MECHANICS OF ENGINEERING

M. 5 and 6. **Mechanics of Engineering.** Sophomores. M. 5 in first term, M. 6 in second term. Credit five hours a term. Prerequisite course Mathematics 6. Theoretical and applied mechanics, including statics, kinetics, and mechanics of materials; resolution, composition, and equilibrium of forces; statics of

rigid bodies, cords and structures; center of gravity and moment of inertia; composition and resolution of displacements, velocities and accelerations; Newton's law; fundamental equations of motion; rectilinear and curvilinear motion of a particle and of rigid bodies; motion diagrams; work, energy, and power, with application to machines; impact; friction; stress and strain; strength and elastic properties of materials in tension, compression, and shearing; torsion; bending moment, safe loading, deflection and resilience in simple and continuous beams; non-prismatic beams; combined bending and torsion; eccentric loading; curved bars and hooks; columns; problems showing application of principles of mechanics in engineering design. Professor WOOD, Assistant Professor GARRETT and Messrs. CORNELL, DAY, HOTCHKISS, PERKINS and SWITZER.

M. 12. **Hydraulics.** Juniors. Second term, credit two hours. Prerequisite courses, M. 5 and 6. Hydrostatics: pressures in containing vessels, centers of pressure, and flotation. Hydrokinetics: flow through orifices and over weirs; general equation of energy; losses of head; flow in pipes and open channels; and dynamic action of streams. Messrs. SWITZER and PERKINS.

M. 21. **Hydraulic Turbines.** Elective. First term, credit two hours. Prerequisite course M. 12. One lecture and one recitation a week. Theory, construction, and installation of modern hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type and size of turbine for any given set of conditions; costs of turbines and water power development. Mr. SWITZER.

DEPARTMENT OF HEAT-POWER ENGINEERING

P. 1. **Engineering Principles.** Freshmen. Either term as assigned, credit one hour. Discussion of the elementary principles that underlie the development of energy from natural sources and its transmission, control and application to human needs. Professor SMITH.

P. 10. **Elementary Heat-Power Engineering.** Required of all juniors. Throughout the year, credit three hours a term. Prerequisite courses Physics 8, 9, and 14, Chemistry 6, M. 5 and 6, and D. 5, 6, and 7. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors, theoretical cycles and general theory of heat engines; application to steam engines and turbines; practical modifications in real engines; engine efficiencies and performances; the indicator card as a measure of work and basis for design; economic features,—reduction of losses by jacketing, superheating, compounding, etc.; application of unaflow and locomobile principles; types of engines; governors. On account of the importance of a thorough understanding of this subject, the student is required to solve a large number of problems in the class room. Professor ELLENWOOD, and Messrs. CLARK, BANKS and GATES.

P. 11. **Heat Engines and Auxiliaries.** Required of C.E. seniors. Either term, credit three hours. Not open to Sibley students. Prerequisite courses Physics 2 and 7, (or the equivalent), Chemistry 1, C.E. 20. One lecture and two recitations a week. Elementary consideration of behavior of gases and vapors. Internal combustion engines. Theory of vaporization. Study of boilers, types of boilers; advantages and disadvantages of various types. Action of vapors in cylinders. Steam engines and turbines; parts and operation; types, advantages

and disadvantages; application; steam consumption and efficiencies. Advantages of condensing; types of condensers; condenser auxiliaries. Contractors' plants. Cost of power.

This course is recommended for all students who wish to obtain a general elementary knowledge of heat-power engineering without great technical detail. Professor ELLENWOOD, and Assistant Professor BERRY.

P. 20. **Power Plant Design.** Required of all regular seniors. Throughout the year, credit three hours per term. Prerequisite course P. 10. One lecture and two recitations a week. A continuation of course P. 10.

Steam turbines; internal combustion engines; fuels; principles of combustion; boiler furnaces and grates; heating surfaces of boilers; types of boilers natural and forced draft; producers; principles governing the transfer of heat; feed water heaters; economizers; superheaters; theory of condensation; types of condensers; condenser pumps; cooling towers and similar devices; water treating apparatus; filters, separators, and similar auxiliary apparatus; flow of steam and gas; refrigerating machinery, and air compressors; elementary theory, types and efficiencies.

Consideration of selection of elements and their combination in power plants, with the object of producing the maximum profit from investment and operation. Professor SMITH, Assistant Professors MATTHEWS and BERRY.

P. 23. **Heat-Power Machinery Design.** Required of seniors in Option B. and not open to others. Throughout the year, credit three hours a term. Prerequisite courses D. 10, D. 16 and P. 10, and must be accompanied by course P. 24. Discussion of types, arrangements, general properties and details of steam and internal combustion engines and their auxiliaries. Power plants. Professor BARNARD and Assistant Professor PEIRCE.

P. 24. **Designing and Drawing.** Required of seniors in Option B, and not open to others. Throughout the year, credit two hours a term. Prerequisite courses D. 10, D. 16 and P. 10 and must be accompanied by P. 23. Two drawing periods per week. The practical solution of problems discussed in P. 23. Professor BARNARD and Assistant Professor PEIRCE.

P. 25. **Steam Turbines.** Senior elective. Required of those taking the design of steam engines in P. 24. Second term, credit two hours. Prerequisite course P. 10. Two lectures a week. Classification of turbines and description of leading features of the various types. Mechanical and thermal considerations underlying the action of steam in turbines. Calculations involved in turbine design. Discussion of building, erecting, and testing. Adaptability to special conditions of service. Economic results of the use of turbines in engineering practice. Professor BARNARD.

P. 28. **Gas Manufacture and Distribution (General).** Seniors. Required of those taking design of internal combustion engines in P. 24. Second term, credit two hours. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. The theoretical and practical principles governing the production and handling of all industrial gases. Assistant Professor PEIRCE.

P. 29. **Gas Power Machinery (General).** Seniors. First term, credit two hours. Not open to students taking Option B. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. General theory and salient points in the design and operation of internal combustion engines and gas producers

Description of existing commercial types, study of relative advantages, and consideration of questions of economy. Assistant Professor PEIRCE.

P. 30. **Steam Boiler Design.** Seniors. First term, credit two hours. Prerequisite courses D. 10, D. 16, and P. 10. Lectures on fuels, combustion, types of boilers, general proportions, materials, design of boiler details, settings, stokers, accessories, and the equipment and arrangement of boiler plants. Professor BARNARD.

P. 31. **Refrigeration and Refrigerating Machinery.** Elective. Second term, credit two hours. Prerequisites P10, D10, 16. Two lectures a week on the principles underlying the various processes used in refrigeration and the machinery employed. Assistant Professor PUTNAM.

P. 32. **Motor Car Construction.** Elective. Second term, credit two hours. Prerequisites P10, D10, 16. Two lectures a week, illustrated by lantern slides showing the structure and development of the motor car. Assistant Professor UPTON.

P. 33. **Heating and Ventilating.** Elective. Second term, credit two hours. Prerequisites P10, D10, 16. Lectures and recitations covering the methods of design and of construction of various forms of ventilating and heating apparatus. Assistant Professor SAMPSON.

P. 40. **Advanced Heat-Power Engineering.** Elective for those who have completed the equivalent of the design subjects in senior Option B. Work and credit as arranged with Professors SMITH and BARNARD.

P. 41. **Readings in English Literature.** Open to juniors and seniors in Sibley College. Two readings a week from Thanksgiving to Easter recess; one hour credit (to be reported in the second term). Credit toward graduation not to exceed one hour in this course. Professor SAMPSON. (For information regarding the course consult Dean Smith.)

DEPARTMENT OF EXPERIMENTAL ENGINEERING

The work in this Department is given in two divisions. One of these is devoted to courses that are required of all students for graduation; the other relates to research courses that are elective.

A. Mechanical Laboratory Division

X. 6. **Manufacture of Engineering Materials.** Required of sophomores. First or second term, credit three hours. Prerequisite course Chemistry 1. Three lectures a week. Metallurgy of iron and steel, copper, etc. Professor DIEDERICHS.

X. 10. **Mechanical Laboratory—Properties of Engineering Materials.** Juniors. First term, credit three hours. Prerequisite courses X. 6, M. 5 and 6. One laboratory period a week. Mechanical strength of materials; tension, torsion, transverse, and compression tests; the variation of the mechanical strength with differences in composition or heat treatment; demonstration of different methods of tempering, annealing, forging, etc. The student is required to write and submit one report each week upon the experiment of the previous week. Assistant Professor UPTON, and Messrs. DIEDERICHS, KLINK, TILLEY and THOMAS.

X. 11. **Mechanical Laboratory—Introductory Experimental Engineering.** Juniors. Second term, credit three hours. Prerequisite courses M. 5 and 6, Chem. 6, Phys. 3. One laboratory period a week as assigned, one written report a

week. Calibration of indicator springs, steam gauges, thermometers, and dynamometers; practice and tests of various computing machines; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; measurement of water; efficiency test of steam engines and pumps, feed water heaters, and condensers. Reports are required and these must include all the data and results of the various tests, together with conclusions. The preparation of the report is considered an important part of the course. Assistant Professor UPTON, and Messrs. DIEDERICHS, KLINK, TILLEY and THOMAS.

X. 12. **Mechanical Laboratory.** For students in Chemical course. Second term only, credit four hours. Prerequisite courses M. 5, and Phys. 10 and 14. One laboratory period (Sat. 8–12) and one report per week. Principal tests on materials of construction; use, adjustment and calibration of common engineering instruments; testing of oils; engine and boiler trials; study of refrigeration, etc. Assistant Professor GAGE and Messrs. DAVIS, HOOK, GAVETT and KNOX.

X. 20. **Mechanical Laboratory—Experimental Engineering.** M.E. Seniors. First term, credit three hours. Prerequisite courses X. 10, 11, P. 10. One laboratory period a week. Efficiency tests of gas and gasoline engines, steam injectors, steam turbine, blowing fan, hydraulic turbine and centrifugal pump; flue gas analysis, etc. Reports are required to be full and complete, to include data and results of each test under consideration, and all information necessary to understand completely the machine tested and the methods used. Assistant Professor GAGE, and Messrs. DAVIS, HOOK, GAVETT and KNOX.

X. 21. **Mechanical Laboratory—General Experimental Engineering.** Seniors in M.E. Second term, credit three hours. One laboratory period a week alternating with one computing period. Written report required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: testing of engines and boilers, air compressors, ice machines; measurement of flow of water, etc. Reports required as in X. 20. Instructing staff as in X. 20.

X. 22. **Mechanical Laboratory.** Required of Seniors in the Electrical Engineering Option. First term, credit two hours. Prerequisites X. 10, 11 and P. 10. Selected experiments from Course X. 20. Instructing staff as in X. 20.

B. Engineering Research Division

X. 30. **Engineering Research.** Elective. Either or both terms; credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have available at least two laboratory periods per week and who have shown proficiency in engineering subjects. Special problems and investigations which are in general carried on in the laboratories under the immediate direction of the members of this department, but which may be carried on in any department of the college under the general supervision of this department. Professor DIEDERICHS, Assistant Professors SAWDON and UPTON, and Mr. MCVETTY.

X. 31. **Power Plant Testing.** Elective. Either term, credit one hour for forty hours of actual work. Open to a limited number of seniors who have shown proficiency in engineering research. Testing of complete power plants as occasion offers. Registration arranged for when opportunities occur. Notices of oppor-

tunities will be posted on the department bulletin board. Professor DIEDERICHS, Assistant Professors SAWDON and UPTON, and Mr. MCVETTY.

X. 32. **Thesis.** Senior elective. Either or both terms, maximum total credit eight hours. If a thesis is elected, permission to carry on the work connected with it must be obtained before Oct. 31. The work on which the thesis is based must be original investigation. All theses are under the general supervision of the Department of Experimental Engineering. The thesis may be a theoretical investigation, a design, experimental work, or other research and may be conducted under the guidance of members of any department of the college, but subject to the general supervision of this department. All students who are considering the preparation of a thesis should consult the head of this department during the junior year if possible. A bound copy of the thesis, in the original typewriting (not a carbon copy) on paper 8 x 10½ inches in size must be deposited before May 15th at the Dean's office, with the approval of the professor in charge of the investigation. This copy becomes the property of the University, and is filed in the General Library where it becomes accessible for reference. Professor DIEDERICHS, Assistant Professors SAWDON and UPTON, and Mr. MCVETTY.

X. 40. **Sibley Journal Credit.** Undergraduate members of the Sibley Journal Board may receive not to exceed two hours of University credit in each term of their senior year (i. e. a maximum credit of four hours) for work satisfactorily done for The Sibley Journal, provided they are elected to the Board in their Sophomore year, or before, and continue as active members on it to the end of the term in which credit is desired.

DEPARTMENT OF ELECTRICAL ENGINEERING

E. 5. **Introductory Course in Electrical Engineering.** Required of all sophomores. Second term only, credit two hours. Two lectures each week. Prerequisite courses Physics 3 and Math. 6. Electric and magnetic circuits; also descriptive work on electrical machinery and its applications. Professor GRAY.

E. 12. **Essentials of Electrical Engineering.** Required of seniors in the civil engineering and chemistry courses. First term only, credit four hours. Two recitations and one laboratory experiment with report each week. The purpose of the course is fourfold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice; (4) to enable the student to read intelligently electrical engineering literature. Assistant Professor PUTNAM and Messrs. BALLARD and COTA.

E. 14. **Elementary Electrical Engineering.** Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours per term. Prerequisite courses Physics 8, 9, 14, M. 5, 6, E5. Must be accompanied by E. 15. One lecture and one computing period a week during both terms. A general course in direct and alternating current circuits and machinery. Professor GRAY, Messrs. TAPPAN and BASON.

E. 15. **Elementary Electrical Engineering.** Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours

per term. Prerequisite courses Physics 8, 9 and 14, M. 5 and 6. Must be accompanied by E. 14. One recitation and one laboratory period per week during the both terms. Experimental work on the subjects taken up in E 14. Professor GRAY and Messrs. PAGE, HUGHES and COTA.

E. 20. **Theory of Electrical Machinery.** Required of seniors in Option A. Throughout the year, credit two hours a term. Prerequisite courses E. 14 and 15. Two lectures a week. First term covers chiefly the laws of the electric and the magnetic circuits; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance, capacity, and iron loss; theory of transmission lines and transformers. Second term is devoted to the theory of transmission lines, transformers, generators, motors, and rotary converters. The lectures are as far as possible correlated with the work in course E. 21. Professor KARAPETOFF.

E. 21. **Characteristics of Electrical Machinery.** Required of seniors in Option A. Throughout the year, credit three hours a term. Prerequisites courses E. 14 and 15. Two recitations and one computing period a week. Problems on the work covered by course E. 20; in particular, performance, characteristics and elementary design of transmission lines, transformers, induction motors, alternators, synchronous motors and converters, and direct-current generators and motors. Professor KARAPETOFF, Assistant Professor PERTSCH and Mr. DEANS.

E. 22. **Electrical Design.** Required of seniors in Option A. Throughout the year, credit two hours a term. Must be accompanied by E 20 and E 21. One recitation and one computing period a week. Principles of commercial design of electrical machinery, and the preparation of specifications. Professor GRAY, Assistant Professor PERTSCH.

E. 23. **Central Stations.** Elective for seniors in E.E. Second term only, credit two hours. One recitation and one computing period a week. Selection, maintenance and operation of equipment also questions of public policy and finance. Assistant Professor PUTNAM.

E. 25. **Elements of Electric Railway Practice.** Elective for seniors. Second term only, credit two hours. Prerequisite courses E. 14 and 15. One recitation and one computing period a week. Apparatus and construction involved in a modern railway system, including cars and car equipment, overhead and track construction, and other topics of similar character. Some attention is devoted to the relation of electric railways to the public and to finance. Mr. CHAMBERLAIN.

E. 27. **Wireless Telegraphy and Telephony.** Elective for seniors in electrical engineering. Second term only, two hours credit. Two recitations a week. Prerequisite courses first term of E. 20, E. 21, and E. 28. Fundamental principles involved in wireless telegraphy and telephony, and study of the development of the application of these principles up to the present status of the art. Mr. BALLARD.

E. 28. **Senior Electrical Laboratory.** Required of seniors in electrical engineering (Option A). Throughout the year, credit four hours a term. Must be accompanied by E 20 and E. 21. Two laboratory periods, one recitation and one report a week. Special and commercial tests on direct and alternating current circuits, generators, motors and other apparatus. Also work on instruments and on electrical materials in the Standardizing Laboratory. The last eight weeks of the second term are devoted to an elaborate piece of experimental work,

which is carried out as a research problem. Assistant Professor FORD, Messrs. CHAMBERLAIN, FLOYD and STEVENS.

E. 30. **Engineering Mathematics.** Elective. Open to seniors and graduate students only. Throughout the year, credit two hours per term. Two recitations a week and home work. General methods by which problems are expressed in mathematical form, studied to establish a better understanding of the unity between the instruction in pure mathematics and the various engineering courses. It is aimed to prepare the student better for engineering research and for the study of advanced engineering literature. The fundamental physical and mathematical assumptions are critically reviewed, and the limitations in the results pointed out. Methods are indicated for obtaining approximate solutions, establishing empirical formulæ, and solving problems by the use of tables, charts, and mechanical devices. The course consists of problems taken in different years from mechanical, civil, and electrical engineering, involving analytic geometry and the elements of differential and integral calculus. The topic will be selected to suit the class. Professor KARAPETOFF and Mr. DEANS.

E. 33. **Special Electrical Engineering Problems.** First or second term or both. Credit two or more hours. Open to seniors. A course to meet the needs of men who are not particularly interested in the other electives. Theoretical and experimental investigations on electrical apparatus. Each student to select his own subject, which however, must meet with the approval of the head of the Electrical Department. Professor KARAPETOFF, and other instructors as required.

E. 36. **Electrical Engineering for M.E. Seniors.** Required of Sibley seniors who take Options B to E, inclusive. Not to be taken simultaneously with E. 37. Two hours credit; repeated in the second term. Prerequisite courses X. 11, E. 14 and E. 15. One lecture and one computing period a week. The course is arranged for the needs of mechanical engineers, particular attention being paid to the operating features of electrical machinery, and to selection of proper electrical apparatus for power and industrial purposes. Professor GRAY, Assistant Professor PUTNAM and Mr. BROWN.

E. 37. **Electrical Engineering for M.E. Seniors.** Required of Sibley seniors who take options B to E inclusive. Not to be taken simultaneously with E. 36. Two hours credit; repeated in the second term. Prerequisite courses X. 11, E. 14 and E. 15. One recitation and one laboratory period per week. A continuation of the electrical laboratory work of course E. 15. Assistant Professor PUTNAM and Mr. STEWART.

Seminar in Electrical Engineering. For seniors and graduate students. No credit. The work that was taken up last year was on polyphase commutating machines and on industrial control. Conducted by Professors GRAY and KARAPETOFF.

[NOTE. For other electrical and illumination courses see under Physics in the Announcement of Courses in the College of Arts and Sciences.]

DEPARTMENT OF INDUSTRIAL ENGINEERING

I. 12. **Industrial Organization.** Required of all juniors in Sibley College and not open to freshmen or sophomores. Open to juniors and seniors of other colleges. First term, credit two hours. A course of lectures on modern industrial tendencies and the principles that underlie modern methods of production. The treatment includes not only the reasons for our changed methods of production but also discussion of the principal features of such industrial factors as factory legislation, factory welfare work, and modern methods of administration. Professor KIMBALL and Mr. MEYLER.

I. 20. **Industrial Administration.** Required of all seniors in Option E. Elective for seniors pursuing other options. Two lectures per week throughout the year, credit two hours per term. Prerequisite course I. 12. A discussion of modern time-keeping and cost-finding systems, methods of planning work and of insuring production, administrative reports, time and motion study, purchasing, etc.; plant location and arrangement, heating, lighting and powering of plants. Professor KIMBALL and Mr. MEYLER.

I. 22. **Drawing and Design.** Required of all seniors in Option E. One recitation and six hours in the drawing room per week throughout the year, credit three hours per term. Prerequisite courses D. 10 and D. 16, and must be accompanied by I. 20.

The work of the first term consists of graphical constructions and their application to administrative problems; graphic planning of organization and the creation of blanks and other administrative documents. In this term each student is required to make a complete outline of the organization of some industrial enterprise either from assumed data or for some plant with which he is familiar.

The work of the second term consists largely of exercises in the location and arrangement of industrial plants from the standpoint of economic production. Each student is required to locate geographically and arrange the plant for which he has made an organization outline in the work of the first term. Professor ALBERT and Mr. MEYLER.

I. 23. **Safety Engineering and Fire Protection.** Required of all seniors in Option E. May be elected by seniors pursuing other options. Two lectures per week during the second term, two hours credit. Prerequisite course I. 12. A discussion of modern factory construction from the standpoint of fire protection and also of safety appliances in connection with factory equipment. Professor WELLS.

I. 40. **Advanced Industrial Engineering.** Open to graduates and seniors who have completed the equivalent of I. 20 and 22. Professors KIMBALL, WELLS and ALBERT.